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By J. F. Scoville

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GENERAL ELECTRIC

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TECHNICAL MANAGEMENT
NASA-LEWIS RESEARCH CENTER
AUXILIARY POWER GENERATION OFFICE
FRANCIS GOURASH

PREPARED FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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GENERAL ELECTRIC

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SUMMARY

~~30~~ 31013

This is the fourth quarterly report for the "Study of Capacitors for Static Inverters and Converters".

The objectives of the study are to establish capacitor AC characteristics and ratings for reliable operation in aerospace static inverter and converter applications and to facilitate minimum capacitor Volume and Weight selection consistent with maximum equipment performance and reliability.

This study was initiated to obtain capacitor AC data and characteristics that are considered essential in the selection of static inverter and converter capacitors for space applications.

General Electric's Specialty Control Department in Waynesboro, Virginia is conducting this study.

This report covers the work accomplished from May 16, 1964 through August 16, 1964 and contains:

a) Capacitor dissipation factor and capacitance versus temperature and frequency.

b) Comparison of metallized paper polycarbonate-foil, and metallized polycarbonate capacitor dissipation factors.

c) Results of a 1000 hour capacitor life test with 400 cps voltage and 85°C ambient.

Author

INTRODUCTION

Capacitors being evaluated in this study are limited to those suitable for use in aerospace static inverters and converters operating in space environments. Inverter rating guides used in this capacitor study are 115/200 volt, 3-phase, 400 cps, 0.1 to 10.0 kilowatt output with input voltage range from 25 to 105 volts D.C.

The need for this study was influenced by the stringent requirements imposed on capacitors by the operating nature of equipment in space environment and by the general lack of capacitor AC characteristics and data.

Heat is generated within commutating and filter capacitors because the volt-ampere-dissipation factor products are appreciable. In commutating capacitors, the volt-ampere product is less than in filter capacitors, but the commutating pulse and ripple frequencies have larger dissipation factors than at the filter capacitor frequency. Transfer of the heat losses within the capacitors are usually limited to conduction across their mounting surfaces to radiator cooling systems on spacecraft. Lack of adequate capacitor AC data and characteristics could result in weight and reliability penalty factors in aerospace static inverter and converter applications.

Objectives of this study are to obtain capacitor AC data and characteristics to facilitate proper capacitor selection for aerospace static inverter and converter applications.

There are four (4) phases in this study: (1) Defining Capacitor State-of-the-Art Survey; (2) Conducting Capacitor State-of-the-Art Survey; (3) Experimental Testing of Capacitors; and (4) Capacitor Evaluation and Recommendations.

During the first three quarterly report periods, the Capacitor State-of-the-Art Survey was defined and conducted. Sample quantities of metallized polycarbonate, polycarbonate/foil and metallized paper capacitors were procured for experimental testing. Results of the survey revealed that polycarbonate dielectric capacitors are considered state-of-the-art capacitors. Metallized polycarbonate capacitors approach metallized paper capacitors in price, weight and volume, but the lower dissipation factors may result in significant weight and volume advantages in certain AC applications. Analysis of commutating capacitor losses, reported in the 3rd. Quarterly Report, illustrated that capacitor losses, while subjected to complex waveforms, may be predicted from capacitor characteristics determined from sinusoidal waveforms.

This is the fourth quarterly report for the work accomplished between May 16, 1964 and August 16, 1964. During this period the experimental testing was in progress. Test results included in this report are capacitance and power factor values versus temperature and frequency and results of 1000 hour capacitor life test at 85°C with 400 cps voltage.

1.0 Capacitance and Disspation Factor Tests

1.1 Purpose

Capacitance and dissipation factor values for polycarbonate and paper capacitors from several manufacturers are being determined by test over a temperature range from - 55°C to + 85°C and frequency range from 400 cps to 10 kilocycles. In addition dissipation factors for a few capacitors are being obtained at frequencies up to 60 and 80 kilocycles. These data will provide equipment designers and capacitor manufacturers with characteristics that will facilitate proper selection of capacitors for aerospace inverter and converter applications. Laboratory temperature and frequency test data are available for dielectric films, but capacitors contain materials other than the dielectric films and require construction techniques which can alter the capacitor characteristics. These construction techniques include mounting of the capacitor roll or stack within the container, end connections to the capacitor and impregnants or fillers if any are used.

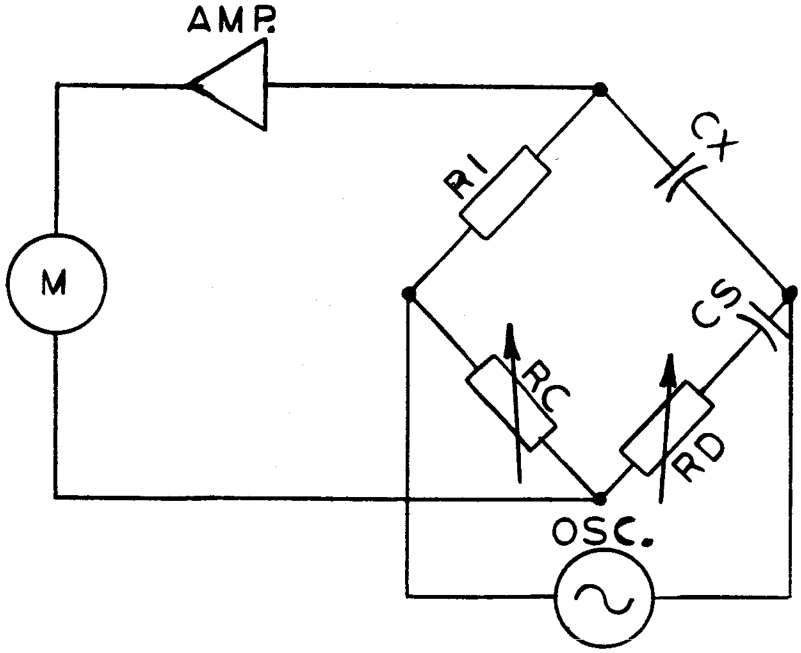
1.2 Description of Tests

Capacitance values were determined with an impedance bridge constructed for these tests. This bridge was constructed with components and interconnections that resulted in a minimum of reactance and therefore little error was introduced by the bridge over the frequency range. An elementary diagram of this type bridge is shown in Figure 1. Capacitance values measured with this bridge compared favorably with values obtained with a General Radio Model 716-C and Sprague Model IW2 capacitance bridges.

Capacitor dissipation factors obtained from the impedance bridge measurements provide comparative data that was adjusted by correction factors obtained from calorimeter heat loss measurements. Adjustment of these dissipation factor data is necessary because unknown and stray capacitances can be appreciable in the range of interest.

Use of the calorimeter is made in measuring the rate of heat being generated from a capacitor immersed in a fluid by observing the rate of temperature rise. Calibration of the calorimeter is accomplished by mounting known values of resistors to the capacitor surface within the calorimeter and measure the direct current flowing in the resistor while observing the rate of temperature rise of the calorimeter fluid. Caution was exercised to obtain the rate of temperature rise after the thermal inertia had been overcome.

Elementary Diagram of Impedance Bridge



R1= 99.7 OHMS; CS=.01MFD., GEN.RADIO STD. 1409L

CX= Capacitor under test

RC= Adjustable resistance (switch, fixed resistors and a potentiometer)

RD= Adjustable resistance (switch, fixed resistor and a potentiometer)

AMP. - Battery operated, single stage, transistor amplifier

M - Harmonic Wave Analyzer - used as null detector

Dissipation Factor $= \frac{R_{cx}}{X_{cx}} = \frac{R_d}{X_{cs}} = RD\omega CS$

Where R_{cx} is the effective resistance of capacitor under test.

Capacitance: $\frac{R1}{RC} = \frac{X_{cx}}{X_{cs}}$ $\quad CX = \frac{CS(RC)}{R1}$

Figure 1

Photographs of the calorimeter, test equipment and calorimeter test specimen mounting were shown in the 3rd. Quarterly Report and are shown in Figures 2 and 3 of this report for convenience to the reader. A calorimeter calibration curve is also repeated for the reader in Figure C1.

Calculation of the rate of heat input is obtained from:

$$I^2R = \text{Watts} = {}^{\circ}\text{C/minute calorimeter fluid}$$

Calculation of the capacitor dissipation factor is calculated from:

$$\text{D.F.} = \frac{\text{Watts}}{\text{Volt-amperes}} \quad \text{where Watts} = \frac{\text{Rate of temperature rise}}{\text{Calibration rate of temperature rise}}$$

Care was exercised to minimize the calorimeter heat loss rate by maintaining the calorimeter fluid temperature within $\pm$ 2°C of the calorimeter external ambient (24 - 26°C within the enclosure). Maintaining the calorimeter fluid within $\pm$ 2°C of the ambient temperature was accomplished by replacement of the fluid between tests.

Impedance bridge measurements at 25°C ambient and up to 10 kilocycles have been made for eighty-five (85) capacitors and correction factors to adjust the bridged dissipation factor values for fifty-five (55) capacitors have been applied.

Capacitance and dissipation factors of seventeen (17) capacitors were measured by the impedance bridge over the temperature range up to 10 kilocycles. Correction factors for eleven (11) of these capacitors have been obtained.

1.3 Results of Tests in 25°C Ambient

Impedance bridge capacitor test data over a frequency range from 0.4 to 10 kilocycles in 25°C ambient with sinusoidal voltage waveform for fifty-five (55) capacitors are tabulated in Tables A-1 through A-3 in Appendix A.

1.3.1 Metallized Polycarbonate Capacitors

Table A-1 contains capacitance and percent dissipation factor test data for twenty-five (25) metallized polycarbonate capacitors.

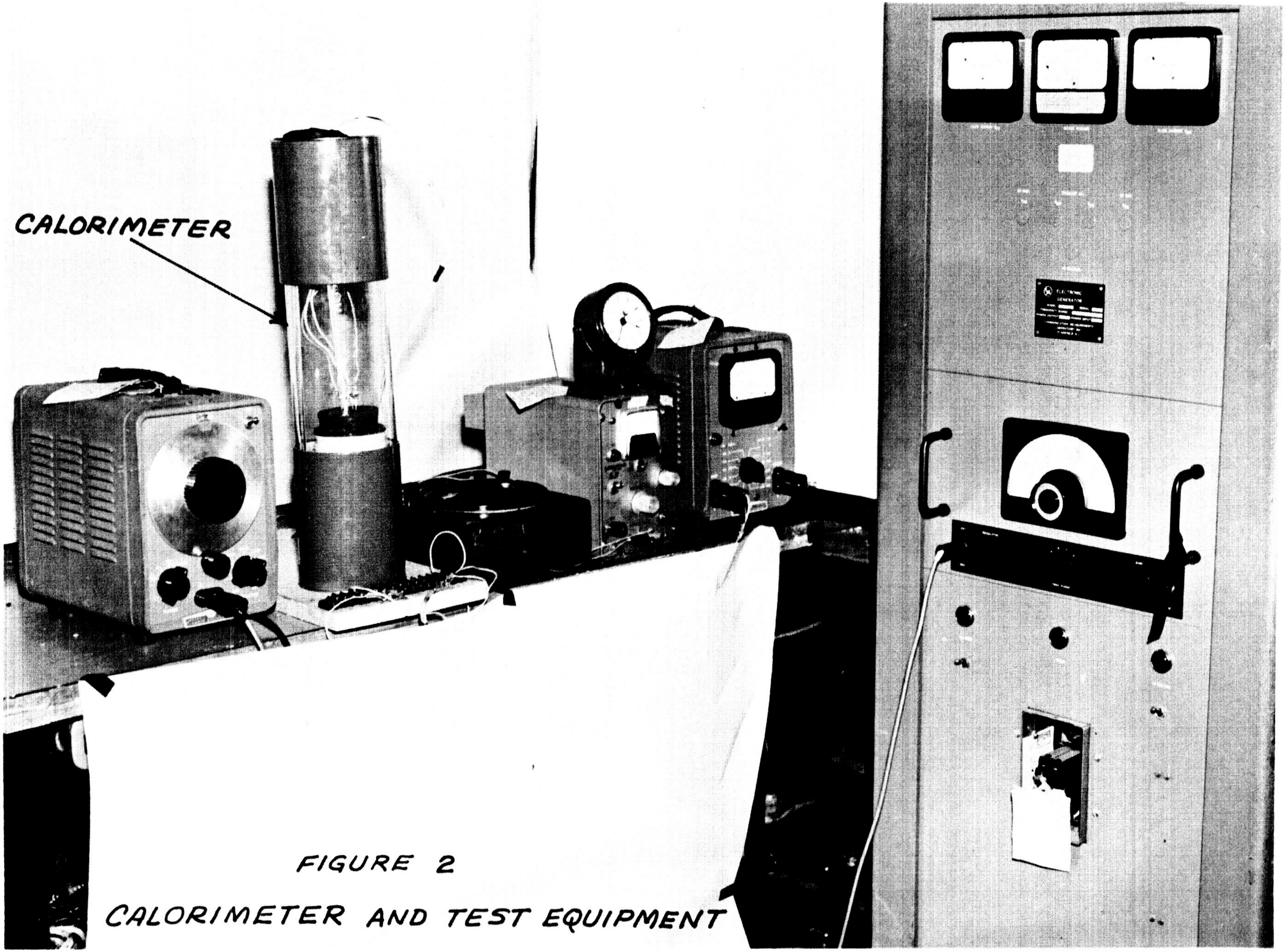


FIGURE 2

CALORIMETER AND TEST EQUIPMENT

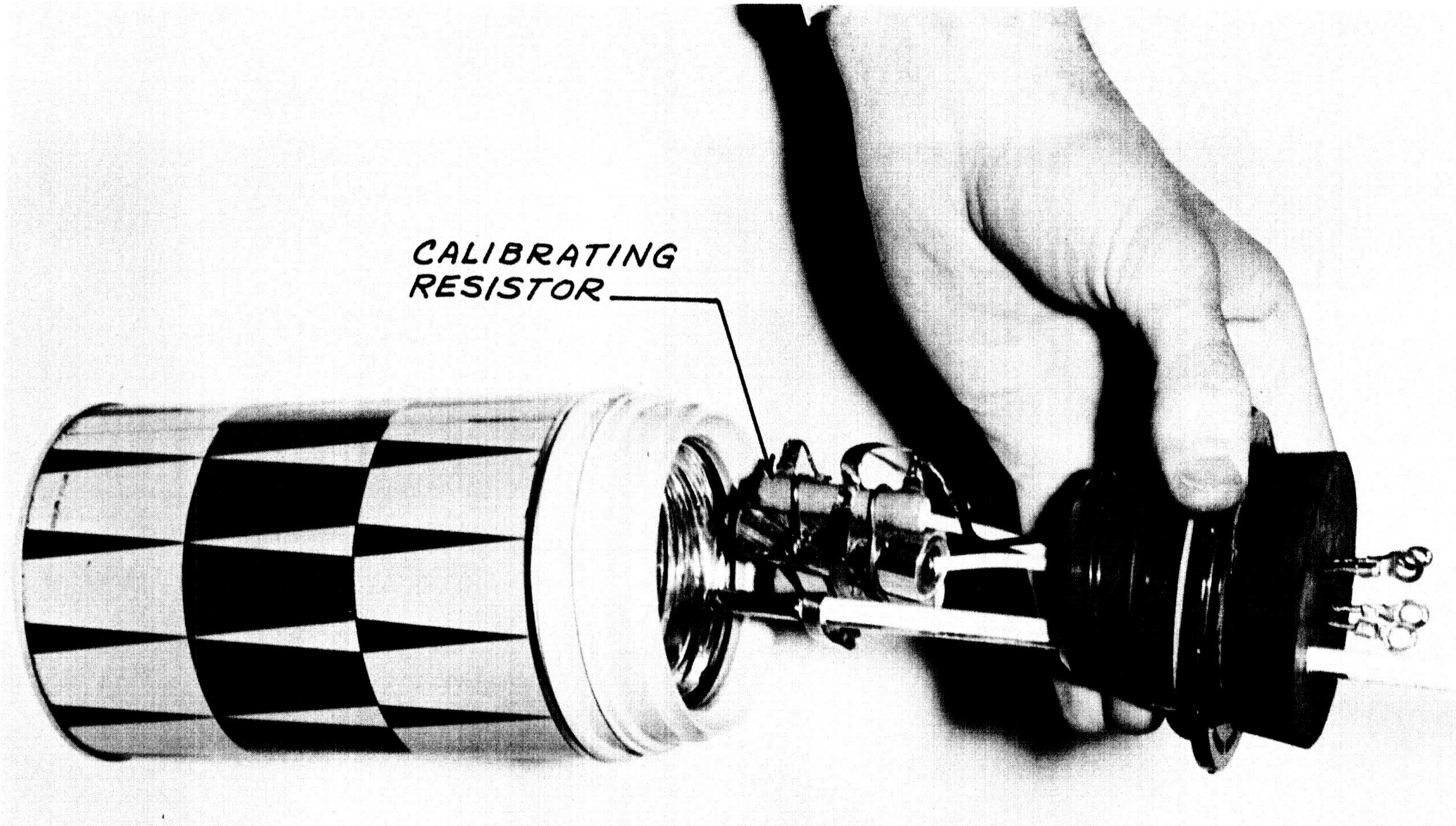


FIGURE 3

TEST SPECIMEN MOUNTING IN CALORIMETER

Capacitor dissipation factor used in this report is defined as the ratio of the resistive component to the capacitive reactance component. The capacitors used in this study have very large capacitive reactance components compared to the resistive components and resulting errors are small as shown below:

$$\frac{Rc}{jXc} = \frac{Rc}{Rc + jXc} \quad \text{where } Rc \ll Xc$$

The curve in Figure A1 illustrates 8.2 percent capacitance variation and 2.7 percent average capacitance variation versus frequency for the capacitors tabulated in Table A-1.

With the exception of capacitors 2B, 2E, 3A through 3E listed in Table A1, the percent dissipation factor (D.F.%) versus frequency for the remaining eighteen (18) capacitors is shown in Figure A2. The variation ranges from 0.092 to 1.020 percent. Capacitor numbers that were excluded from the data presentation in Figure A2 were considered to have excessively high dissipation factor percentages by comparison with the remaining eighteen (18).

Manufacturers of the seven (7) capacitors with the high dissipation factors are being advised of these test results and effort will be made to determine the cause for the high dissipation factors.

1.3.2 Polycarbonate/Foil Capacitors

Table A-2 contains capacitance and percent dissipation factor test data for fifteen (15) polycarbonate/foil capacitors.

The composite curve in Figure A3 illustrates 10.5 percent capacitance variation versus frequency and average capacitance variation of 2.8 percent for the capacitors tabulated in Table A-2.

Dissipation factor variation from 0.05 to 0.24 percent versus frequency is shown in Figure A4 for the capacitors tabulated in Table A-2.

Figure 6 contains the percent dissipation factor up to 50 and 80 kilocycles for capacitor numbers 9B, 10A, and 11A. Capacitor number 10A has the highest dissipation factor of 2.64 percent at 60 kilocycles. Dissipation factor data for a 2 MFD, 400 VDC metallized paper capacitor is also plotted in Figure 6 for reference purposes.

1.3.3 Metallized Paper Capacitors

Capacitance and percent dissipation factor test data for fifteen (15) metallized paper capacitors are tabulated in Table A-3.

Figure A5 illustrates a capacitance variation versus frequency of 3.7 percent and an average capacitance variation of 1.3 percent for the capacitors tabulated in Table A-3.

Dissipation factor variation versus frequency from 0.19 to 1.54 percent for the capacitors tabulated in Table A-3 is shown in Figure A6.

1.3.4 Comparison of Capacitor Types

Comparison of the average data plotted in Figures 1A, 2A, 3A, 4A, 5A and 6A are presented for convenience to the reader in Figures 4 and 5. From these graphs, one may observe that the dissipation factor for polycarbonate/foil capacitors is approximately one quarter (1/4) as large as that for metallized paper capacitors. Also the dissipation factor for metallized polycarbonate capacitors is approximately two-thirds (2/3) that of metallized paper capacitors.

Variation of the average percent capacitance variation is less than 1.6 percent between the three (3) types of capacitors.

The dissipation factor for polycarbonate film is considerably smaller than for paper dielectrics used in capacitors. However, part of this material advantage may not be realized if capacitor end connections and conductive elements contribute resistive losses approaching the same order of magnitude as the dielectric material.

The difference in dissipation factors between metallized paper and metallized polycarbonate capacitors would appear to be attributed largely to the dielectric material advantage of polycarbonate. The difference in dissipation factors between metallized polycarbonate and polycarbonate/foil capacitors appear to be attributed to capacitor end connections and less resistance in the thicker foil, as the capacitor conductive element, than the thinner metallized conductive element.

Average Percent Capacitance Versus Frequency in 25°C Ambient

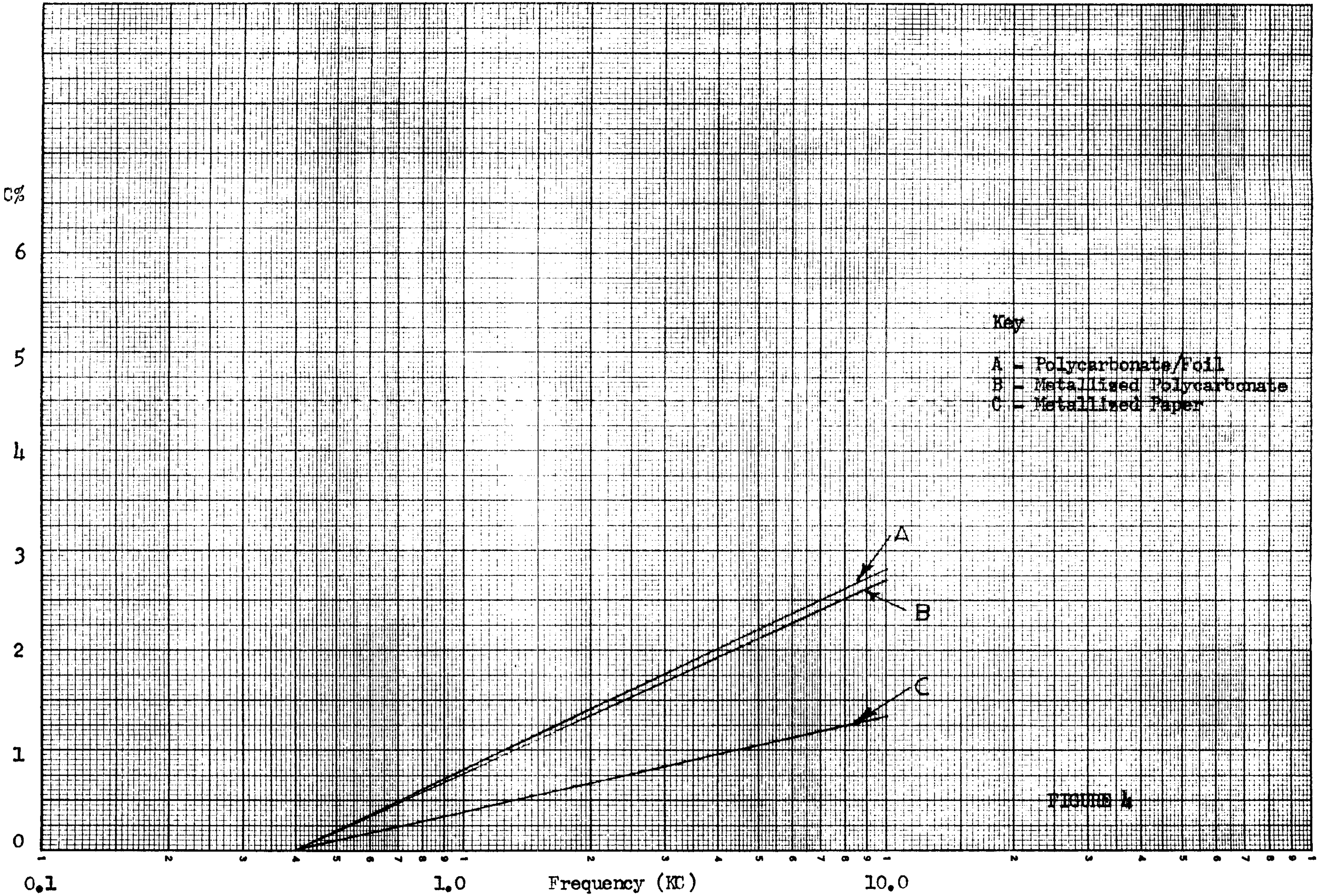


FIGURE 4

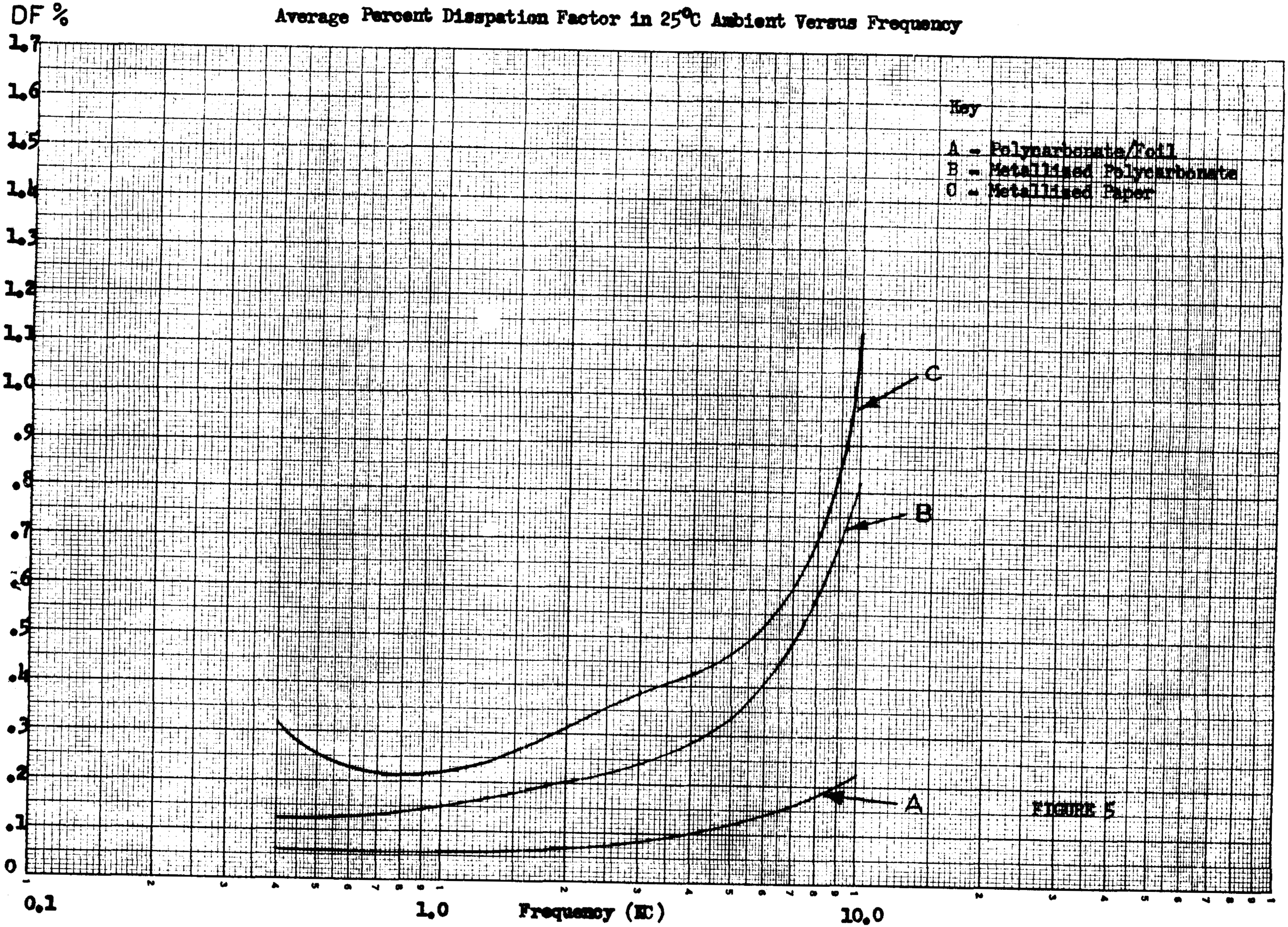

DF %
Average Percent Dissipation Factor in 25°C Ambient Versus Frequency
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
0.1
1.0
10.0
Frequency (KC)
Key
A - Polycarbonate/Foil
B - Metallized Polycarbonate
C - Metallized Paper
A
B
C

FIGURE 5

Percent Dissipation Factor in 25°C Ambient Vs. Freq. (0.4 to 80 KC)

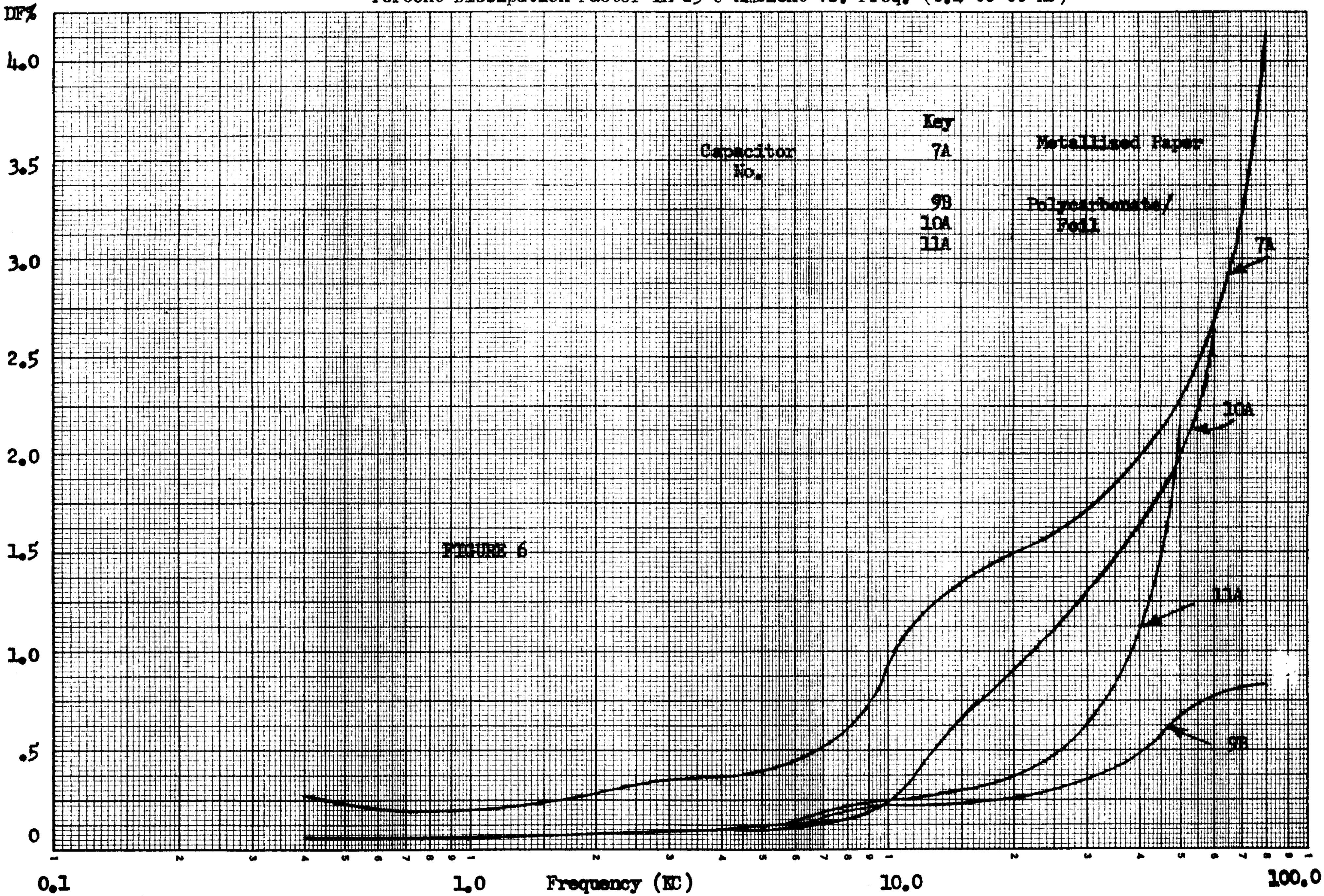


FIGURE 6

Although metallized paper capacitors have larger dissipation factors than polycarbonate capacitors, they exhibit smaller percent capacitance change versus frequency in 25°C ambient. This smaller percent change of capacitance is believed to be attributed to a slightly decreasing capacitance characteristic with increasing frequency for impregnated paper dielectrics if it is assumed that the series inductive elements from construction methods in the paper and polycarbonate capacitors are identical.

1.4 Results of Tests Versus Temperature and Frequency

Impedance bridge capacitor test data in ambient temperatures from - 55°C to + 85°C over a frequency range of 0.4 to 10 kilocycles with sinusoidal voltage waveform for eleven (11) capacitors are tabulated in Tables A-4 through A-6 in Appendix A.

1.4.1 Metallized Polycarbonate Capacitors

Table A-4 contains capacitance and dissipation factor test data for five (5) metallized polycarbonate capacitors. A variation of - 2.0 to + 1.6 percent capacitance referenced to 25°C values versus frequency and temperature, for the capacitors listed in Table A-4, is shown in Figure A7. With the exception of capacitor numbers 2E and 3D, a variation from 0.09 to 1.23 percent dissipation factor versus frequency and temperature is shown in Figure A8 for the remaining capacitors listed in Table A-4. Exclusion of the dissipation factor data for capacitor number 2E from Figure A8 was done because the dissipation factor percent in -55°C ambient was considered to be abnormally high and a function of either construction techniques or material other than metallized polycarbonate film. Similarly, data for capacitor number 3D was excluded from Figure A8, because the high dissipation factor may be a function of construction techniques.

1.4.2 Polycarbonate/Foil Capacitors

Capacitance and dissipation factor test data for three (3) polycarbonate/foil capacitors are tabulated in Table A-5.

Variation of - 2.1 to + 0.65 percent capacitance for the three (3) capacitors listed in Table A-5 is illustrated in Figure A9. With the exclusion of dissipation factor test data for capacitor number 10A, a variation from 0.03 to 0.275 percent dissipation factor for the other two (2) capacitors in Table A-5 is illustrated in Figure A10. Exclusion of the dissipation factor data for capacitor number 10A from Figure A10 was done because of the relatively high percent dissipation factor in - 55°C ambient that may be a function of construction technique or material other than the dielectric.

1.4.3 Metallized Paper Capacitors

Capacitance and dissipation factor test data for three (3) metallized paper capacitors are tabulated in Table A-6.

Percent capacitance variation from - 13.75 to + 3.0 percent referenced to 25°C values for the capacitors listed in Table A-6 is illustrated in Figure A11. Percent dissipation factor variation from 0.175 to 1.44 percent for the capacitors listed in Table A-6, with the exception of capacitor number 8A, is illustrated in Figure A12. Exclusion of the percent dissipation factor data for capacitor number 8A from Figure A12 was for the same reason for the exclusion of data for capacitor number 10A in paragraph 1.4.2 above.

1.4.4 Comparison of Capacitor Types

Comparison of the dissipation factor data plotted in Figures A8 through A12 are presented in Figure 7 to illustrate the differences of the three (3) types of capacitors tested in this study. In comparison with metallized paper capacitors, polycarbonate/foil capacitors have dissipation factors of approximately one-fourth (1/4) and metallized polycarbonate capacitors have values approximately one half (1/2) to two-thirds (2/3).

The capacitor dissipation factor data in Figure 7 are based on:

A) Polycarbonate/foil - Three capacitors from 2 manufacturers
B) Metallized Polycarbonate - Two capacitors from 2 manufacturers
C) Metallized Paper - Two capacitors from 1 manufacturer

These capacitor dissipation characteristics plotted in Figure 7 are considered to be typical for the capacitor types indicated because 25°C ambient data for a larger number of similar capacitors listed in Tables A1 through A3 exhibit relatively small variation of dissipation factors between manufacturers except those capacitors previously mentioned in paragraphs 1.4.1, 1.4.2 and 1.4.3 above.

FN-265-A (8-50) GENERAL ELECTRIC COMPANY. SCHENECTADY, N. Y., U.S.A. 3 cyc. x 170 1mm Divisions

Percent Dissipation Factor Versus Frequency and Temperature

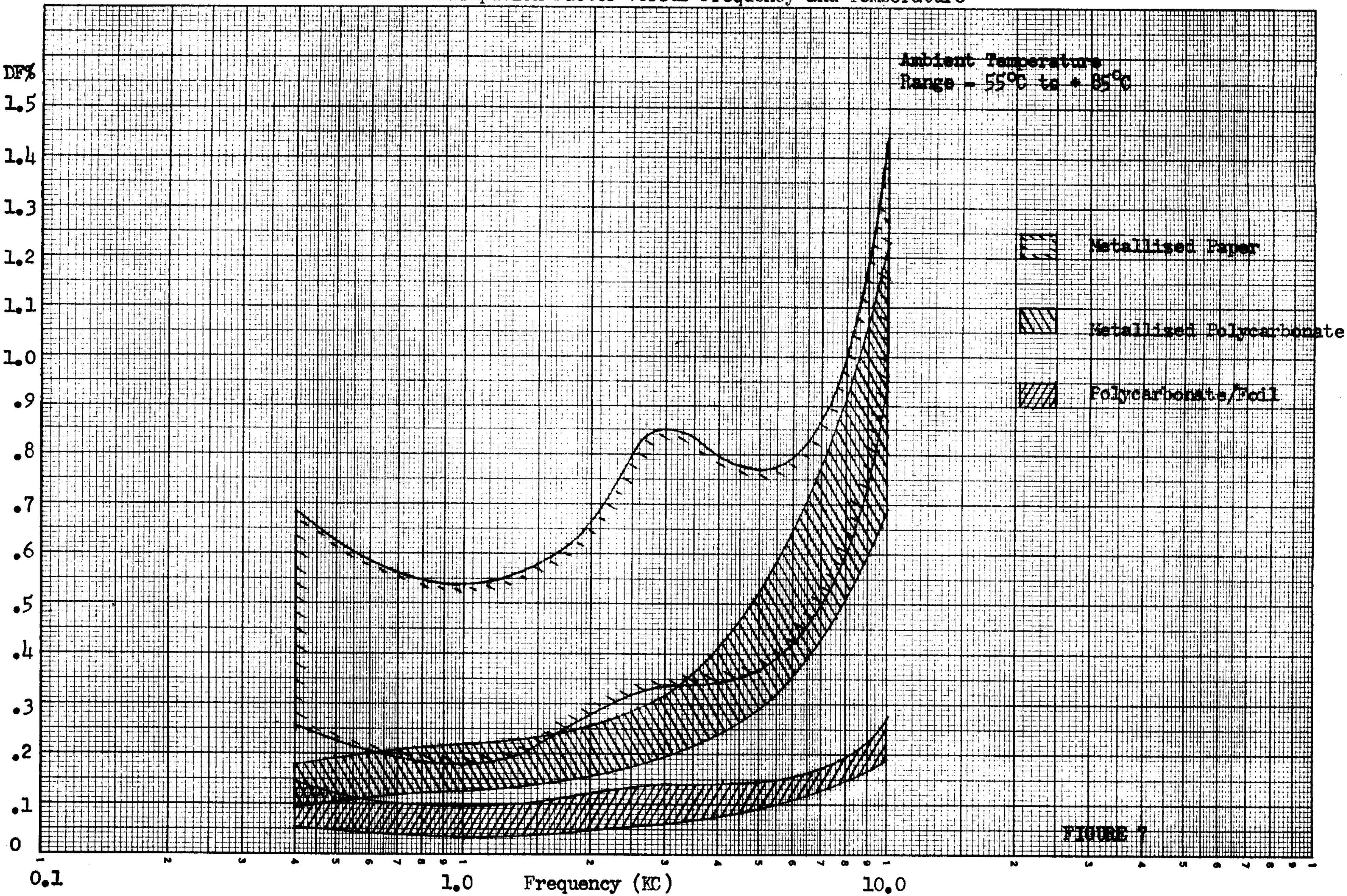


FIGURE 7

A tabulation of the tubular capacitor sizes and weights by type is presented in Table I. In the 400 VDC ratings, the ratio of the average volume/capacitance of metallized polycarbonate to metallized paper capacitors is 116 percent and similarly the ratio for the 200 VDC ratings is 138 percent. This 22 percent increase in volume/capacitance ratio from the 400 VDC to the 200 VDC ratings may be attributed to a minimum polycarbonate film thickness limitation.

The volume/capacitance ratio between polycarbonate/foil and metallized paper capacitors is 250 percent for the 400 VDC ratings and 450 percent for the 200 VDC ratings. From these large ratios, it appears that the foil thickness may approach the polycarbonate film thickness.

The pounds/capacitance for metallized polycarbonate is approximately the same as for metallized paper capacitors. Larger physical size of the polycarbonate capacitors, compared with metallized paper, account for the larger pounds/capacitance figure.

2.0 Capacitor Life Test

2.1 Purpose

A total of fifty (50) capacitors were subjected to an abbreviated life test of 1000 hours in 85°C ambient. This test was conducted to determine if the capacitors could withstand AC peak voltages equivalent to the DC voltage ratings with the exception of DC voltage ratings above corona starting voltage region.

2.2 Description of Test

The fifty (50) capacitors (33 metallized polycarbonate, 12 polycarbonate/foil and 5 metallized paper capacitors) were mounted on the inner walls of a sealed aluminum box, shown in Figure 8. The surface of the aluminum box was maintained at a temperature of 85 ± 3°C for the duration of the life test. Figure 9 shows the indicating lights that are in parallel with the fuses in each capacitor circuit illustrated in the elementary diagram in Figure B1 in Appendix B.

The rating of the fuses in series with the capacitors were selected to be approximately three (3) times the rated capacitor current. Detection of a shorted capacitor during the test was revealed by the indicator light that was on, indicating the fuse had open circuited.

Tabulation of Capacitor Tubular Sizes and Weights

Capacitor Identification No.	Rating 400 VDC	Rating 200 VAC	Type	in^3/uF	Average Vol./uF/Type	#/uF
1A-1E	1 uF		MPC	0.91		.063
2A-2E	2 uF		MPC	0.94	0.93	.062
3A-3E	2.5 uF		MPC	1.03		.059
5A-5E	2 uF		MPC	.84		.053
7A-7E	2 uF		MP	.89	0.80	.064
8A-8E	2 uF		MP	.71		.052
9A-9E	1 uF		PCF	2.06	2.06	.145
12A-12E		3 uF	MPC	0.35		.023
13A-13E		3 uF	MPC	0.28		.018
14A-14E		3 uF	MPC	0.56*	0.29	.036
15A-15E		3 uF	MPC	0.24		.017
4A-4E		2 uF	MP	0.22		.018
16A-16E		3 uF	MP	0.21	0.21	.016
10A-10E		2 uF	PCF	0.93	0.93	.069

Key: MPC - Metallized Polycarbonate
MP - Metallized Paper
PCF - Polycarbonate/Foil

* Omitted in the Average Vol/uF/Type figure

TABLE I

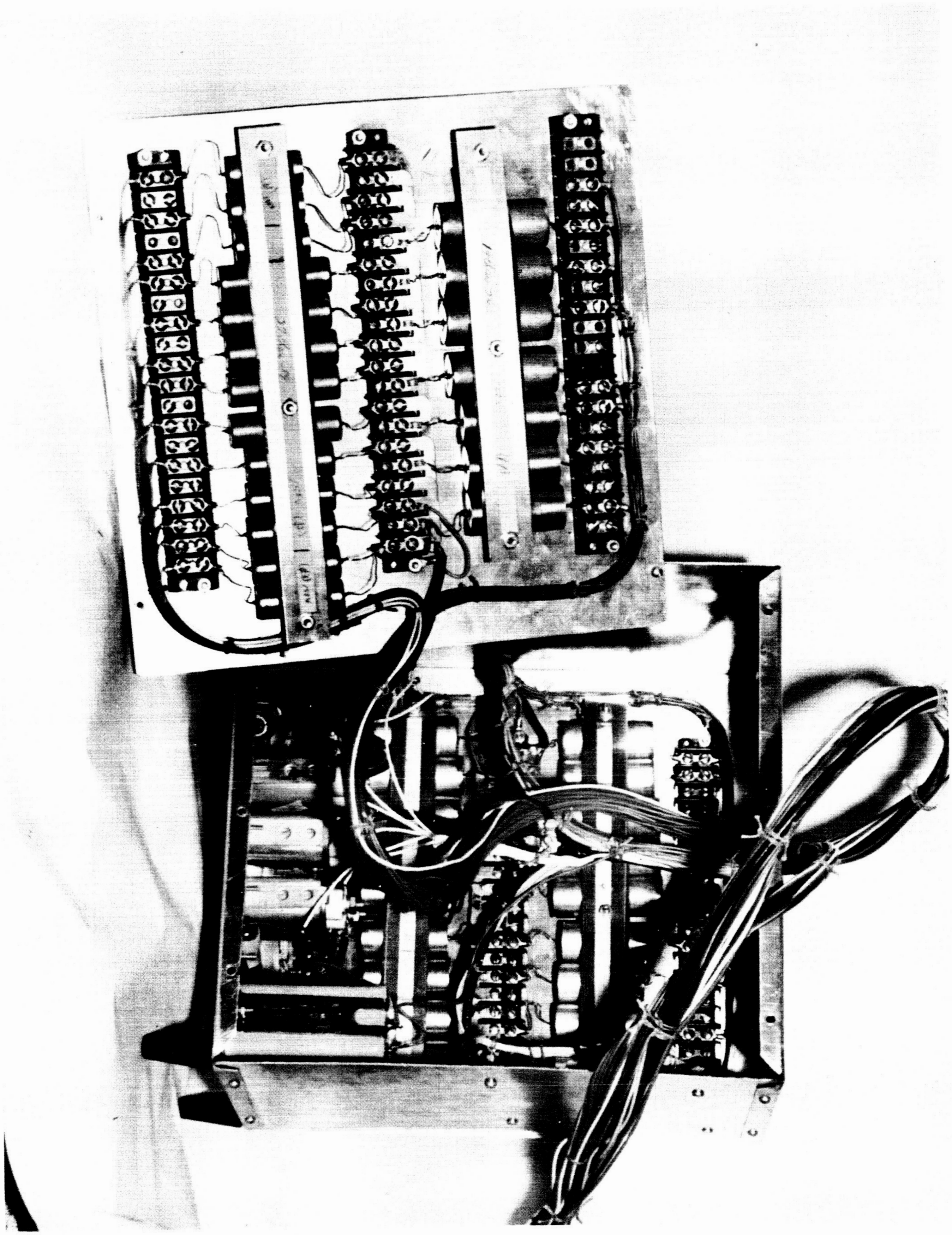


FIGURE 8 Mounting of Life Test Capacitors

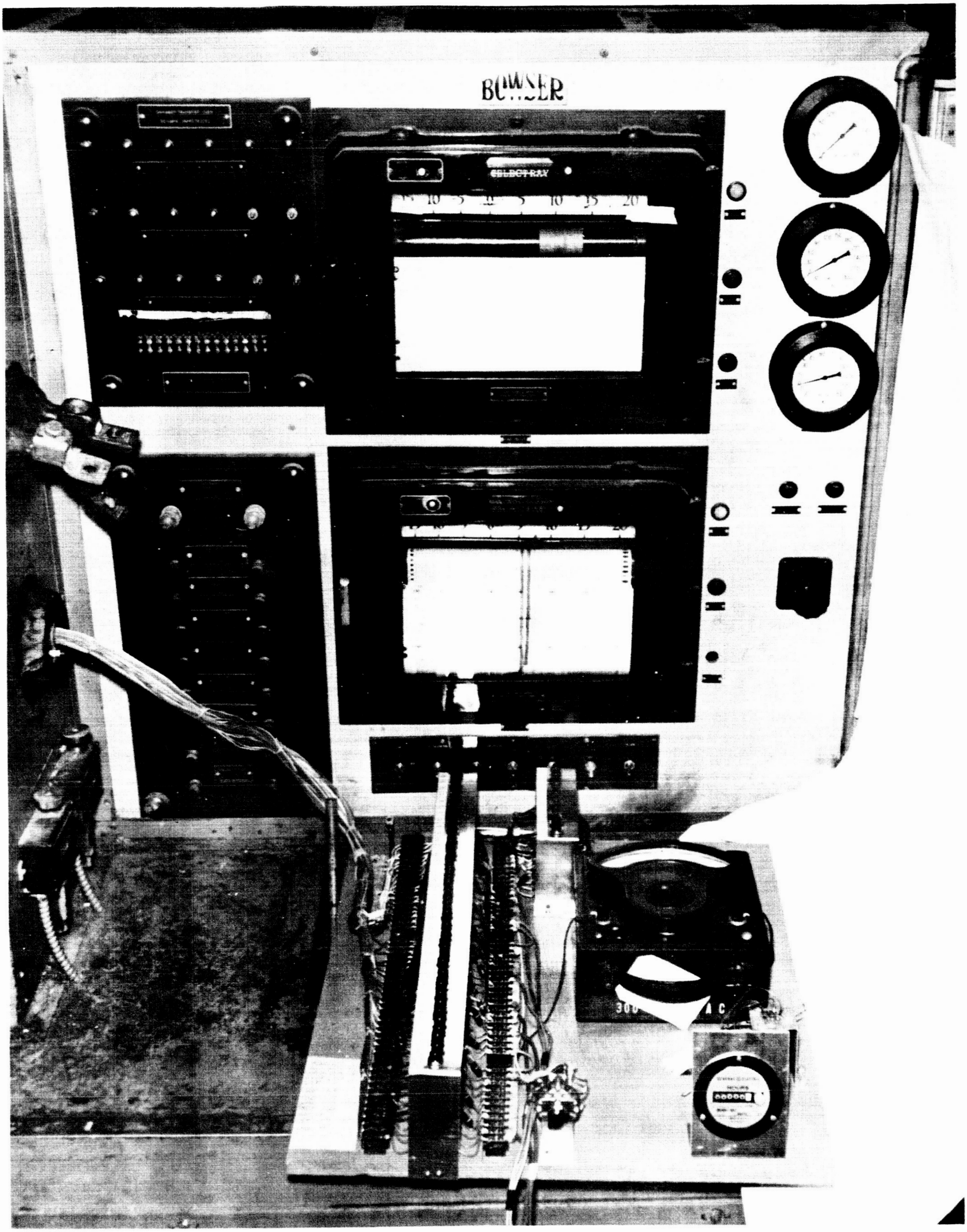


FIGURE 9 Life Test Monitoring Equipment

Capacitors that may have failed in an open circuit mode only would have been detected when capacitance and dissipation factor data were taken at the conclusion of the test.

All capacitors were energized with 420 cps voltage with peak voltage comparable to the capacitor DC voltage rating with the exception of the 400 VDC ratings which were energized with 325 volt peak. The 325 peak voltage is approaching the corona start region.

A strip chart temperature recorder shown in Figure 9, was used to monitor the temperature of the aluminum box containing the capacitors. The 420 cps voltage was monitored twice during each normal working day during the test. An elapsed time indicator was energized from the 420 cps voltage source to indicate total test time.

2.3 Results of Test

There were thirteen (13) capacitors that failed during the life test. The types that failed by developing short circuits were:

Qty	Type	Rating
3	Polycarbonate/foil	1 MFD, 400 VDC
3	Polycarbonate/foil	2 MFD, 200 VDC
3	Metallized Polycarbonate	2 MFD, 400 VDC
4	Metallized Polycarbonate	3 MFD, 200 VDC

Capacitors 3, 4, 5, 11 in Figure 1B developed short circuits upon step application of the 230 volt RMS, 420 cps power. This step application of power resulted in two (2) 350 V RMS transients and three (3) 280 V RMS transients from resonant effects between the capacitors and the transformer inductance.

Capacitors 20, 21, 23 and 30 in Figure 1B developed short circuits upon application of power.

The following capacitors developed short circuit during the life test as tabulated:

Capacitor No.	Hours to Failure
13	234.7
32	362.7
12, 33	474.8
31	666.7

The capacitors that failed during this test were from one (1) capacitor manufacturer. The fifty (50) capacitors subjected to this life test were obtained from six (6) capacitor manufacturers. Capacitors that developed short circuits during this life test are being returned to the capacitor manufacturer for determination for cause of failure.

3.0 Work Planned for the Next Report Period

Completion of this study has been rescheduled from August 16, 1964 to October 16, 1964 to permit analysis and reporting of reasons for large dissipation factor variation versus frequency and temperature, determination of causes for capacitor failure in life test and to complete calorimeter testing of larger 3 and 5 microfarad capacitors to obtain correction factors for bridge data.

4.0 Conclusions

Reduction of commutating capacitor heating will be achieved if the equipment designer can reduce or eliminate high frequencies from being impressed on the capacitor because the dissipation factor increases rapidly with frequency above 10 kilocycles as illustrated in Figure 6.

In thermally limited applications, capacitor dissipation factors should be specified for the temperatures and frequencies of interest to facilitate prediction of performance.

Polycarbonate/foil capacitors exhibit small dissipation factors over the temperature range from - 55°C to + 85°C and up to 50 kilocycles.

Size and weight limitations for capacitor ratings of 10 microfarads or larger may be imposed by heat generation and transfer in some applications. Metallized polycarbonate capacitors, that exhibit smaller dissipation factors than metallized paper, may offer appreciable size and weight advantages in the voltage range of 200 to 250 volts RMS for the following reasons:

1) Polycarbonate film has a higher dielectric strength and therefore requires less thickness and volume than paper.

2) Polycarbonate film has a smaller dissipation factor than paper and more capacitance may be packaged in a container to achieve the same heat generation as paper.

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Attn: K. A. More (1)

The Bendix Corporation
Red Bank Division
1900 Hulman Building
Dayton, Ohio
Attn: R. N. Earnshaw (1)

VARO, Incorporated
2201 Walnut Street
Garland, Texas
Attn: J. H. Jordan (1)

Aerospace Corporation
P. O. Box 95085
Los Angeles 45, California
Attn: Library Technical Documents Group (1)

Engineered Magnetics Division
Gulton Industries, Incorporated
13041 Cerise Avenue
Hawthorne, California
Attn: Burton J. McComb (1)

AiResearch Mfg. Co.
Div. of the Garrett Co.
P. O. 5217
Phoenix, Arizona 85010
Attn: Mrs. J. F. Mackenzie, Librarian (1)

General Dynamics Astronautics
Dept. 963-2
5001 Kearney Villa Rd.
San Diego, California
Attn: R. Schaelchlin (1)

Prestolite
Toledo, Ohio
Attn: J. F. Carey (1)

Director of Research Lab for the Engr. Science
Thornton Hall
University of Virginia
Charlottesville, Virginia
Attn: A. R. Kuhlthau (1)

Radiation Effects Information Center
Battelle Memorial Institute
505 King Ave.
Columbus, Ohio 43201
Attn: E. N. Wyler (1)

APPENDIX A

Capacitance and Dissipation Factor Test Data

Data contained in Tables A1 through A6 were obtained by bridge measurement and calorimeter data with sinusoidal voltage waveforms.

An example of the dissipation factor corrections applied to the bridge data is given here:

From Table A1, capacitor No. 1A, the dissipation factor as determined from the bridge data at 10 kilocycles is 1.110%. As measured by the calorimeter, the dissipation factor at 10 kilocycles is .975%.

By ratio of the bridge data of the dissipation factor for capacitor number 1B and 1A, the corrected dissipation factor for capacitor 1B at 10 kilocycles is:

$$\frac{.958\%}{1.110\%} \times .975 = .840\%$$

Test data for capacitor numbers 2E, 2B, 3A through 3E in Table A1 were not included in the plotted results in Figure A2. The reader is referred to page 3 for reasons of omission.

Test data for capacitor numbers 2E and 3D in Table A4 were not included in the plotted results in Figure A8. Also test data for capacitor numbers 10A in Table A5 and 8A in Table A6 were not included in the plotted results in Figures A10 and A12 respectively. The reader is referred to pages 4 and 5 of this report for reasons of omission.

25 °C TEST DATA FOR

METALLIZED POLYCARBONATE CAPACITORS

	CALCULATED FROM BRIDGE MEASUREMENTS										CALCULATED FROM CALORIMETER DATA					CORRECTED BRIDGE					
	C (MFD)					DF (%)					DF (%)					DF (%)					
FREQUENCY (KC)	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	
CAPACITOR NO.																					CAPACITOR RATING
1A	.965	.980	.983	.984	.991	.731	.361	.408	.581	1.110	.142	.151	.222	.400	.975	-	-	-	-	-	
1B	.970	.984	.986	.988	.998	.671	.316	.367	.507	.958	-	-	-	-	-	.130	.132	.198	.343	.840	
1C	.981	.995	.999	1.000	1.010	.660	.330	.366	.525	.971	-	-	-	-	-	.128	.138	.199	.362	.852	1 MFD, 400 VDC
1D	.952	.965	.967	.969	.975	.676	.353	.379	.540	1.020	-	-	-	-	-	.131	.148	.206	.372	.895	
1E	.950	.963	.966	.967	.952	.690	.361	.428	.614	1.160	-	-	-	-	-	.134	.151	.233	.424	1.020	
2A	2.179	2.192	2.198	2.206	2.238	.529	.346	.537	.844	1.650	-	-	-	-	-	.095	.124	.209	.318	.790	
2B	2.183	2.195	2.201	2.207	2.238	.555	.430	.797	1.280	2.500	-	-	-	-	-	.100	.154	.312	.482	1.200	2 MFD 400 VDC
2C	2.170	2.181	2.187	2.194	2.211	.536	.387	.646	1.030	2.040	-	-	-	-	-	.096	.138	.252	.388	.975	
2D	2.203	2.216	2.222	2.229	2.263	.509	.348	.558	.874	1.710	-	-	-	-	-	.092	.124	.218	.330	.818	
2E	2.140	2.153	2.159	2.166	2.197	.579	.499	1.000	1.620	3.280	.104	.178	.390	.610	1.570	-	-	-	-	-	
3A	2.683	2.688	2.703	2.712	2.763	.503	.340	.569	.904	1.810	-	-	-	-	-	.166	.178	.363	.577	1.240	
3B	2.668	2.686	2.689	2.690	2.703	.682	.837	2.040	3.250	5.830	-	-	-	-	-	.225	.436	1.300	2.060	3.980	2.5 MFD 400 VDC
3C	2.639	2.651	2.658	2.668	2.718	.503	.348	.369	.893	1.770	-	-	-	-	-	.166	.183	.233	.569	1.215	
3D	2.672	2.688	2.690	2.700	2.739	.637	.708	1.680	2.750	5.470	.210	.370	1.070	1.750	3.740	-	-	-	-	-	
3E	2.649	2.662	2.671	2.681	2.731	.489	.354	.607	.965	1.890	-	-	-	-	-	.162	.186	.386	.613	1.292	
5A	1.920	1.934	1.940	1.947	1.971	.525	.336	.490	.744	1.470	-	-	-	-	-	.094	.134	.191	.280	.703	
5B	1.945	1.956	1.961	1.967	1.992	.531	.332	.479	.726	1.410	-	-	-	-	-	.095	.132	.187	.274	.675	2 MFD 400 VDC
5C	1.916	1.931	1.936	1.941	1.967	.590	.343	.484	.736	1.470	-	-	-	-	-	.105	.136	.189	.277	.703	
5D	1.949	1.963	1.968	1.974	2.001	.530	.337	.502	.773	1.510	-	-	-	-	-	.095	.134	.196	.291	.723	
5E	1.950	2.002	2.006	2.012	2.040	.530	.332	.492	.753	1.450	-	-	-	-	-	.095	.132	.192	.283	.693	
6A	1.970	1.981	1.986	1.991	2.017	.544	.390	.611	.943	1.890	-	-	-	-	-	.098	.139	.238	.355	.907	
6B	1.956	1.967	1.972	1.977	2.003	.519	.388	.409	.740	1.380	-	-	-	-	-	.093	.121	.191	.278	.662	2 MFD 300 VDC
6C	1.910	1.923	1.927	1.938	1.958	.549	.379	.582	.882	1.390	-	-	-	-	-	.099	.135	.227	.332	.669	
6D	2.008	2.020	2.025	2.031	2.060	.547	.395	.650	1.010	1.980	-	-	-	-	-	.098	.141	.254	.380	.951	
6E	1.953	1.965	1.970	1.974	2.004	.551	.381	.591	.913	1.790	-	-	-	-	-	.099	.136	.231	.343	.860	

TABLE A1

25°C TEST DATA FOR
POLYCARBONATE/FOIL CAPACITORS

	CALCULATED FROM BRIDGE MEASUREMENTS C (MFD)					CALCULATED FROM BRIDGE MEASUREMENTS DF (%)					CALCULATED FROM CALORIMETER DATA DF (%)					CORRECTED BRIDGE DF (%)					
FREQUENCY (KC)	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	CAPACITOR RATING
CAPACITOR No.																					
9A	.842	.856	.857	.858	.864	.719	.310	.296	.422	.763	-	-	-	-	-	.108	.056	.084	.104	.234	1 MFD 400 VDC
9B	.840	.852	.855	.856	.861	.712	.306	.292	.401	.763	.107	.055	.083	.101	.234	-	-	-	-	-	
9C	.842	.858	.860	.861	.867	.708	.338	.303	.415	.774	-	-	-	-	-	.106	.061	.086	.106	.237	
9D	.841	.856	.858	.859	.865	.695	.323	.294	.412	.774	-	-	-	-	-	.104	.058	.084	.104	.237	
9E	.839	.857	.859	.860	.866	.692	.316	.298	.412	.773	-	-	-	-	-	.104	.057	.085	.104	.236	
10A	1.967	1.910	1.985	1.991	2.019	.503	.332	.523	.821	1.660	.057	.055	.116	.140	.226	-	-	-	-	-	2 MFD 200 VDC
10B	1.972	1.984	1.990	1.995	2.024	.499	.330	.526	.821	1.690	-	-	-	-	-	.056	.055	.116	.140	.230	
10C	1.973	1.986	1.991	1.997	2.025	.499	.327	.519	.813	1.650	-	-	-	-	-	.056	.054	.115	.138	.225	
10D	1.973	1.985	1.991	1.997	2.024	.502	.332	.526	.823	1.670	-	-	-	-	-	.057	.055	.116	.140	.227	
10E	1.968	1.981	1.985	1.992	2.020	.506	.329	.518	.811	1.650	-	-	-	-	-	.057	.054	.115	.139	.225	
11A	3.094	3.108	3.117	3.131	3.200	.480	.367	.695	1.110	2.310	.052	.038	.068	.102	.202	-	-	-	-	-	3 MFD 135 VAC
11B	3.047	3.059	3.069	3.082	3.150	.489	.385	.751	1.250	2.590	-	-	-	-	-	.053	.040	.073	.116	.227	
11C	2.950	2.963	2.972	2.985	3.048	.481	.365	.665	1.080	2.260	-	-	-	-	-	.052	.038	.065	.100	.198	
11D	3.085	3.097	3.107	3.121	3.193	.495	.377	.720	1.160	2.420	-	-	-	-	-	.054	.039	.070	.108	.212	
11E	3.006	3.018	3.028	3.043	3.107	.496	.379	.694	1.140	2.400	-	-	-	-	-	.054	.039	.068	.106	.210	

TABLE A2

25°C TEST DATA FOR METALLIZED PAPER CAPACITORS

FREQUENCY (KC)	C (MFD) calculated from bridge measurements .4	1	3	5	10	DF (%) calculated from bridge measurements .4	1	3	5	10	DF (%) calculated from calorimeter data .4	1	3	5	10	DF (%) corrected bridge .4	1	3	5	10	CAPACITOR RATING
CAPACITOR NO.																					
4A	1.838	1.843	1.839	1.849	1.855	1.170	1.030	1.325	1.630	2.520	-	-	-	-	-	.351	.248	.440	.460	1.115	2 MFD 200VDC
4B	1.847	1.850	1.848	1.849	1.867	1.320	1.030	1.360	1.740	2.730	-	-	-	-	-	.396	.248	.455	.490	1.205	
4C	1.933	1.939	1.934	1.935	1.951	1.170	1.100	1.570	2.110	3.490	-	-	-	-	-	.351	.266	.524	.596	1.545	
4D	1.865	1.871	1.867	1.868	1.886	1.130	1.010	1.290	1.620	2.460	-	-	-	-	-	.338	.244	.431	.457	1.090	
4E	1.859	1.864	1.859	1.860	1.877	1.120	1.010	1.310	1.650	2.550	-	-	-	-	-	.336	.244	.438	.465	1.127	
7A	1.863	1.871	1.870	1.871	1.889	.917	.793	1.050	1.370	2.160	.275	.192	.351	.386	.955	-	-	-	-	-	2 MFD 400VDC
7B	1.848	1.856	1.853	1.856	1.875	.905	.776	1.030	1.340	2.170	-	-	-	-	-	.271	.188	.345	.378	.960	
7C	1.858	1.868	1.866	1.869	1.887	.906	.768	1.020	1.320	2.090	-	-	-	-	-	.272	.186	.341	.372	.925	
7D	1.852	1.860	1.858	1.859	1.878	.912	.782	1.030	1.340	2.170	-	-	-	-	-	.274	.189	.345	.378	.960	
7E	1.862	1.870	1.868	1.871	1.889	.917	.788	1.050	1.360	2.160	-	-	-	-	-	.275	.191	.351	.384	.955	
8A	2.175	2.181	2.178	2.184	2.212	1.010	.908	1.250	1.640	2.730	1.010	.908	1.250	1.640	2.730	.302	.220	.417	.462	1.205	2 MFD 400VDC
8B	2.160	2.167	2.163	2.167	2.193	1.000	.899	1.220	1.630	2.710	1.000	.899	1.220	1.630	2.710	.300	.218	.408	.462	1.200	
8C	2.164	2.171	2.169	2.170	2.199	1.020	.914	1.240	1.620	2.700	1.020	.914	1.240	1.620	2.700	.306	.221	.414	.462	1.198	
8D	2.183	2.189	2.186	2.188	2.215	1.010	.908	1.250	1.660	2.750	1.010	.908	1.250	1.660	2.750	.302	.220	.417	.468	1.215	
8E	2.161	2.167	2.164	2.167	2.195	1.050	.937	1.270	1.820	2.730	1.050	.937	1.270	1.820	2.730	.315	.226	.424	.512	1.205	

TABLE A3

Percent Capacitance Variation Versus Frequency in 25°C Ambient
Metallized Polycarbonate

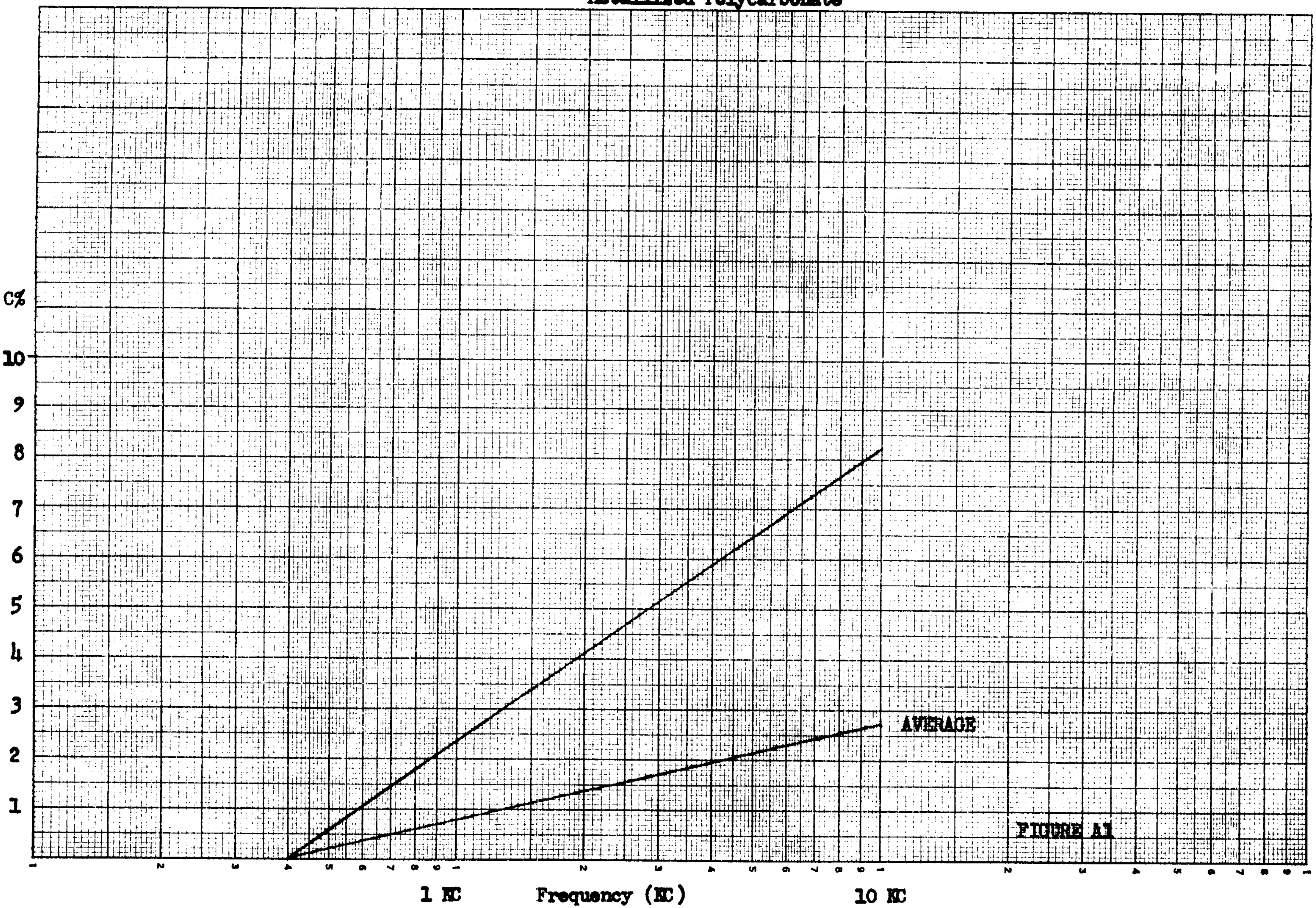


FIGURE A1

Percent Dissipation Factor Versus Frequency in 25°C Ambient
Metallized Polycarbonate

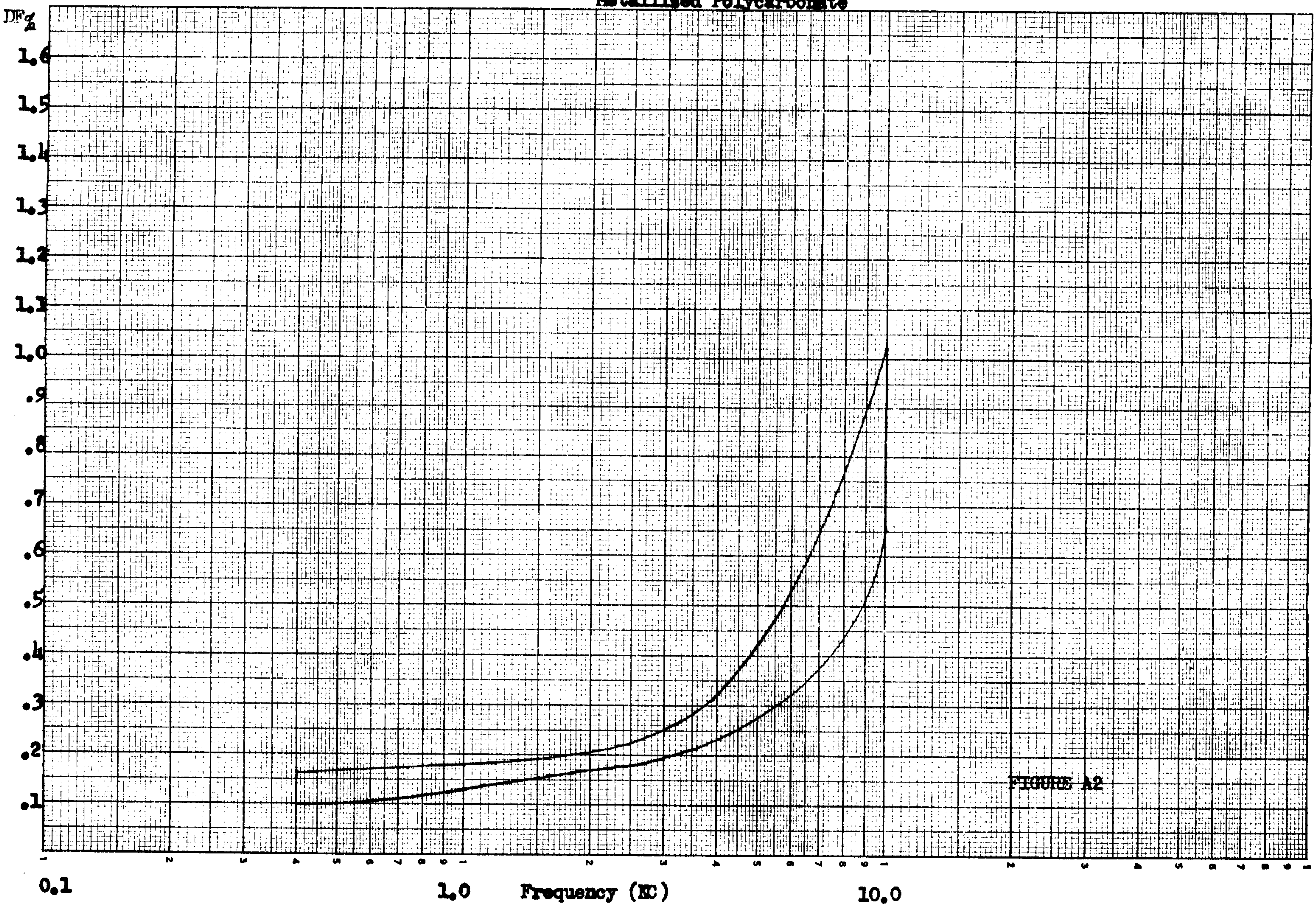


FIGURE A2

Percent Capacitance Versus Frequency in 25°C Ambient
Polycarbonate/Foil

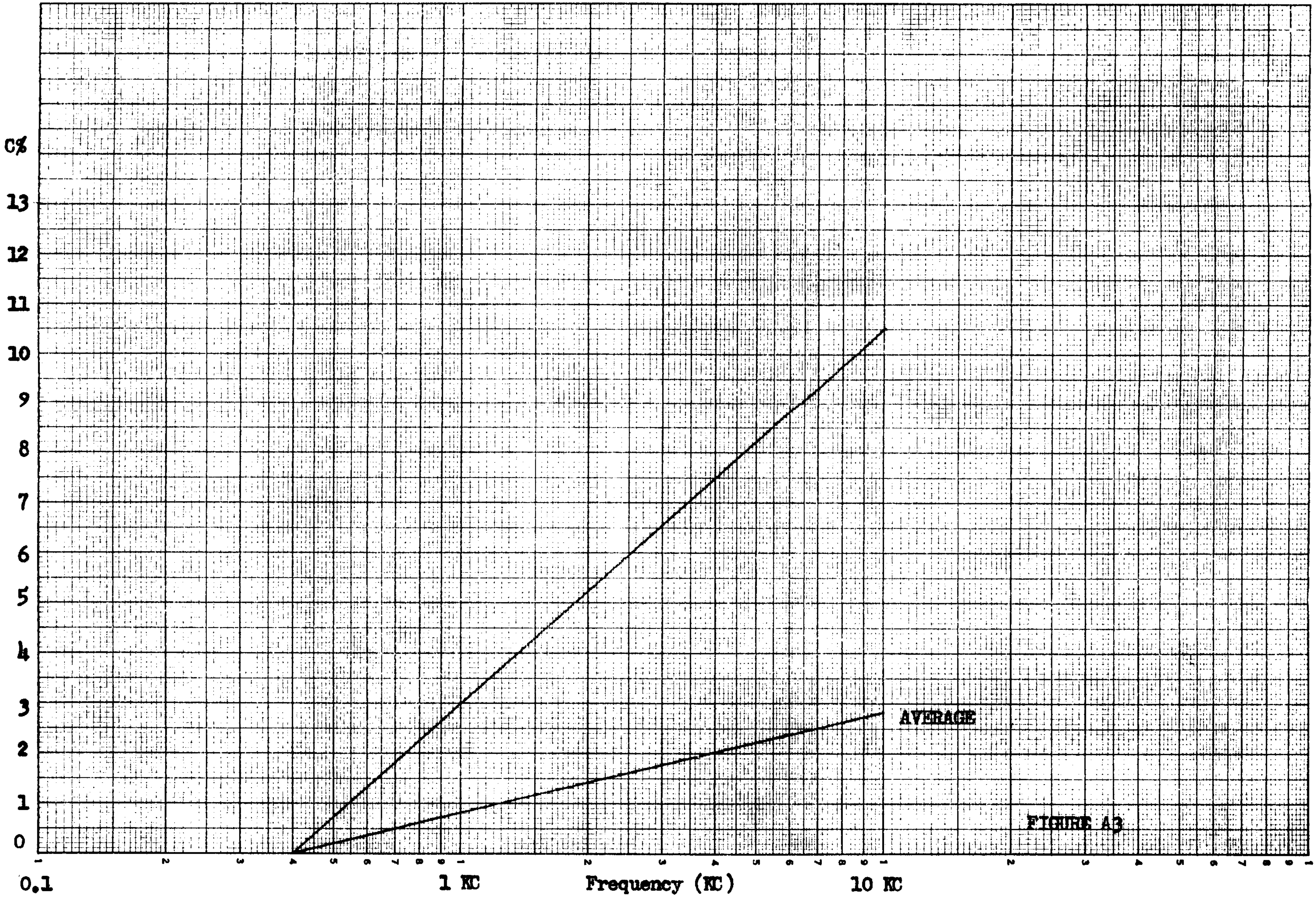


FIGURE A3

Percent Dissipation Factor Versus Frequency in 25°C Ambient
Polycarbonate/Foil

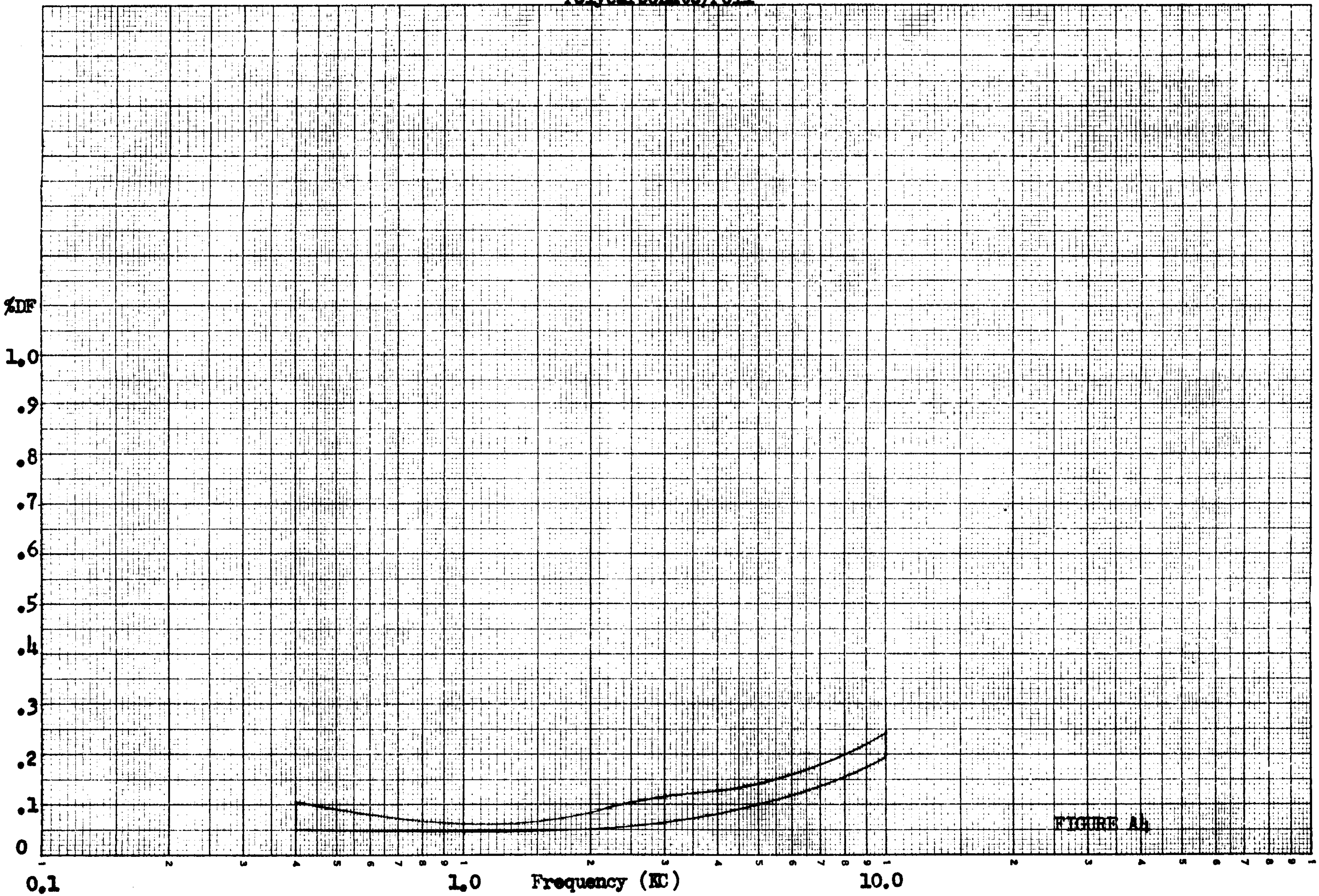


FIGURE A4

Percent Capacitance Versus Frequency in 25°C Ambient
Metallized Paper

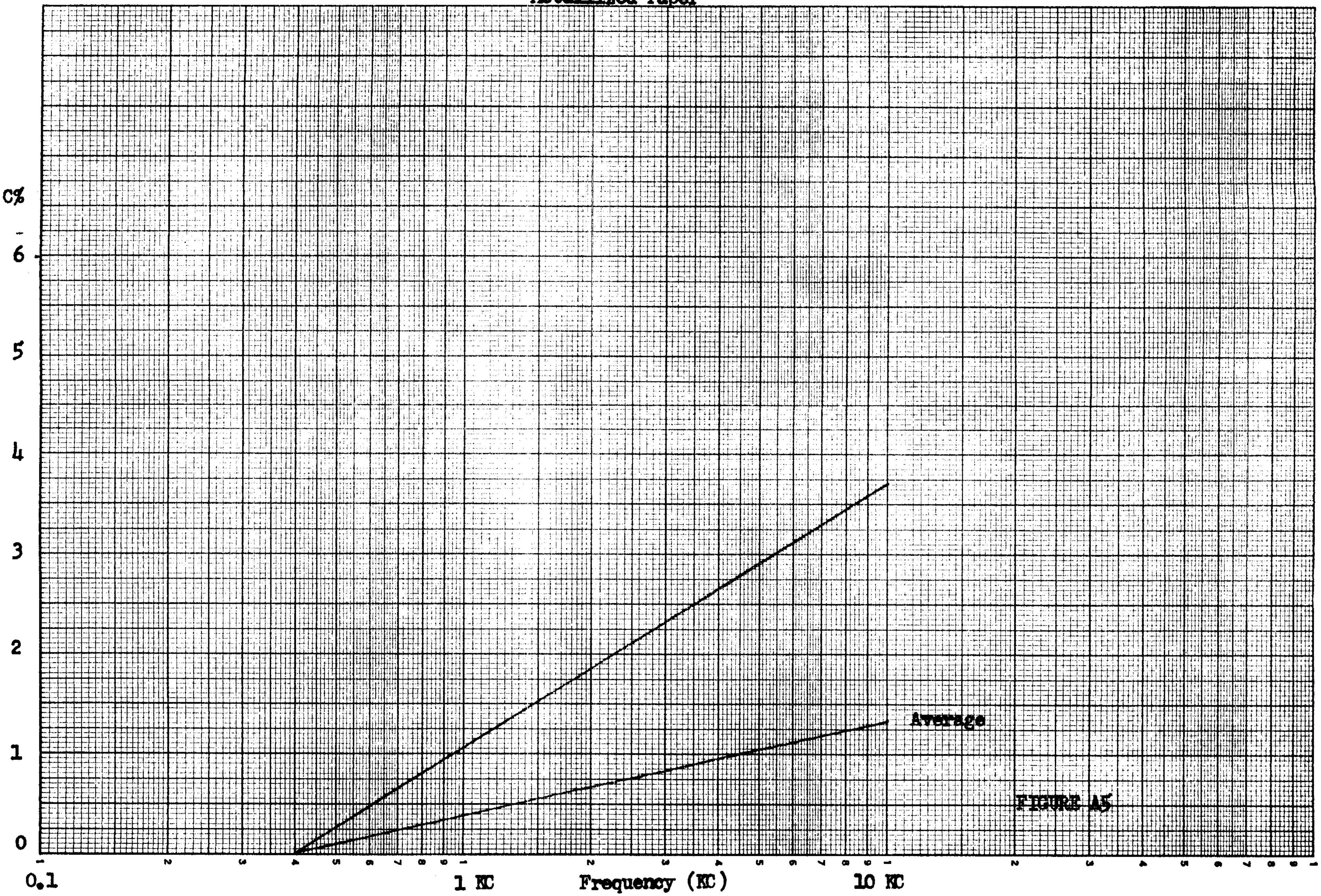


FIGURE A5

FN-265-A (8-50) GENERAL ELECTRIC COMPANY. SCHENECTADY, N. Y., U.S.A. 3 cyc. x 170 1mm Divisions

Percent Dissipation Factor Versus Frequency in 25°C Ambient
Metallized Paper

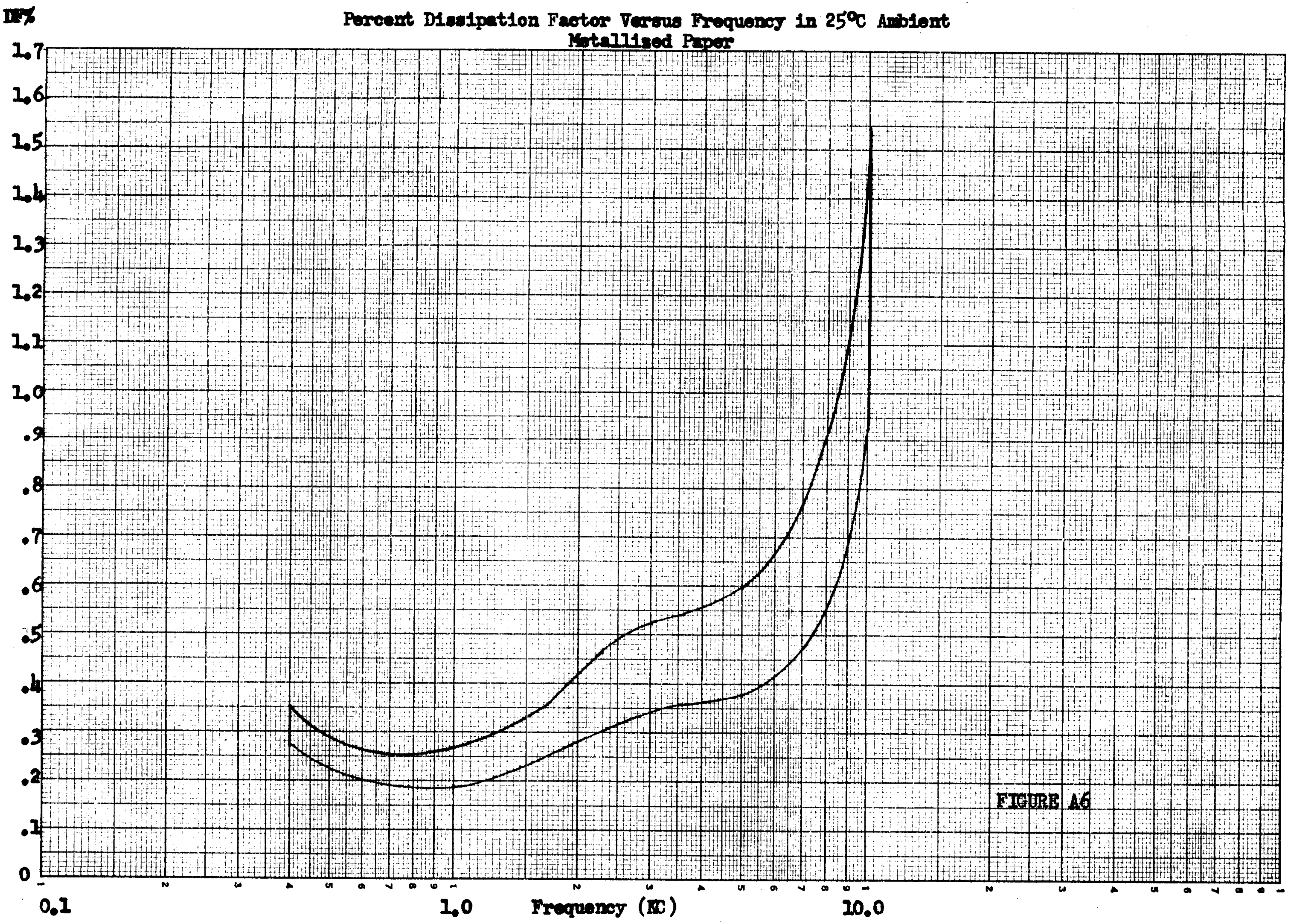


FIGURE A6

CAPACITOR TEST DATA VERSUS TEMPERATURE

FOR METALLIZED POLYCARBONATE CAPACITORS

	CALCULATED FROM BRIDGE MEASUREMENTS										CORRECTED BRIDGE					
	C (MFD)					DF (%)					DF (%)					
FREQUENCY (KC)	4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	
CAPACITOR No.																AMBIENT TEMPERATURE
1A	.975	.987	.990	.993	1.008	.688	.449	.657	1.000	2.000	.132	.140	.221	.407	1.025	+85°C
2E	2.155	2.166	2.175	2.187	2.248	.724	.876	2.210	3.660	7.610	.108	.194	.447	.702	1.800	
3D	2.617	2.632	2.641	2.657	2.725	.792	1.120	2.920	4.830	9.650	.209	.384	1.125	1.850	3.950	
5E	1.989	2.002	2.009	2.010	2.083	.554	.456	.915	1.520	3.030	.092	.128	.192	.290	.702	
6C	1.890	1.931	1.937	1.947	1.997	.548	.470	.969	1.580	3.300	.091	.128	.228	.355	.739	
1A	.965	.977	.982	.982	.992	.743	.485	.659	.981	1.900	.142	.151	.222	.400	.975	+25°C
2E	2.140	2.152	2.157	2.174	2.233	.694	.804	1.930	3.180	6.630	.104	.178	.390	.610	1.570	
3D	2.662	2.674	2.684	2.701	2.773	.798	1.080	2.780	4.570	9.140	.210	.370	1.070	1.750	3.740	
5E	1.989	2.002	2.009	2.020	2.076	.574	.471	.912	1.480	2.990	.095	.132	.192	.283	.693	
6C	1.912	1.922	1.929	1.938	1.988	.593	.490	.961	1.480	2.980	.099	.135	.227	.332	.669	
1A	.962	.969	.975	.877	.900	.758	.574	.873	1.290	2.390	.144	.179	.294	.523	1.230	-25°C
2E	2.148	2.142	2.148	2.158	2.216	.815	1.030	.245	3.940	8.000	.127	.228	.495	.757	1.895	
3D	2.671	2.678	2.683	2.698	2.778	.930	1.190	2.780	4.460	8.800	.245	.408	1.070	1.710	3.600	
5E	1.979	1.990	1.994	2.001	2.056	.709	.626	1.080	1.630	3.180	.118	.175	.227	.312	.738	
6C	1.901	1.912	1.915	1.924	1.970	.721	.638	1.110	1.650	3.110	.120	.176	.259	.370	.698	
1A	.951	.965	.966	.969	.980	.898	.708	.930	1.260	2.180	.171	.220	.314	.513	1.120	-55°C
2E	2.118	2.127	2.129	2.139	2.193	1.690	3.010	7.980	13.080	26.610	.253	.618	1.610	2.510	6.300	
3D	2.649	2.659	2.662	2.678	2.757	.990	1.210	2.680	4.260	8.420	.261	.414	1.030	1.630	3.45	
5E	1.965	1.975	1.979	1.987	2.040	.818	.763	1.270	1.840	3.25	.135	.214	.267	.351	.753	
6C	1.887	1.896	1.900	1.908	1.952	.806	.698	1.230	1.790	3.360	.134	.190	.290	.402	.753	

TABLE A 4

CAPACITOR TEST DATA VERSUS TEMPERATURE
FOR POLYCARBONATE/FOIL CAPACITORS

	CALCULATED FROM BRIDGE MEASUREMENTS										CORRECTED BRIDGE										
	C (MFD)					DF (%)					DF (%)										
FREQUENCY (KC)	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	AMBIENT TEMPERATURE
CAPACITOR No.																					
9A	.843	.854	.857	.859	.869	.690	.402	.505	.746	1.420	.108	.056	.084	.104	.234						+25 °C
10A	1.968	1.979	1.987	2.000	2.046	.618	.622	1.380	2.270	4.640	.057	.055	.116	.140	.226						+25 °C
11A	3.089	3.103	3.120	3.150	3.305	.587	.632	1.480	2.460	5.260	.052	.038	.068	.102	.202						+25 °C
9A	.847	.859	.862	.865	.874	.683	.384	.465	.702	1.280	.107	.053	.077	.101	.210						+85 °C
10A	1.976	1.990	1.997	2.002	2.059	.584	.564	1.290	2.150	4.360	.054	.050	.108	.132	.212						+85 °C
11A	3.058	3.073	3.092	3.124	3.269	.595	.589	1.380	2.310	5.110	.053	.035	.063	.096	.197						+85 °C
9A	.839	.851	.852	.855	.862	.794	.539	.528	.859	1.520	.124	.075	.088	.119	.251						-25°C
10A	1.959	1.965	1.975	1.985	2.032	.827	1.020	2.330	3.740	7.500	.076	.093	.196	.230	.366						-25°C
11A	3.096	3.105	3.120	3.147	3.293	.683	.722	1.500	2.390	4.990	.061	.043	.068	.097	.192						-25°C
9A	.835	.835	.846	.847	.854	.934	.694	.823	1.040	1.680	.146	.097	.137	.144	.276						-55°C
10A	1.947	1.957	1.959	1.966	2.011	1.750	3.130	8.350	13.820	27.700	.162	.276	.702	.853	1.352						-55°C
11A	3.089	3.097	3.109	3.136	3.282	.803	.837	1.700	2.630	5.190	.072	.050	.078	.110	.200						-55°C

TABLE A5

CAPACITOR TEST DATA VERSUS TEMPERATURE

FOR METALLIZED PAPER CAPACITORS

	CALCULATED FROM BRIDGE MEASUREMENTS										CORRECTED BRIDGE					
	C (MFD)					DF (%)					DF (%)					
FREQUENCY (Kc)	.4	1	3	5	10	.4	1	3	5	10	.4	1	3	5	10	
CAPACITOR No.																AMBIENT TEMPERATURE
4A	1.865	1.874	1.867	1.886	1.932	.876	.818	1.380	2.040	3.850	.256	.174	.356	.399	1.060	+85°C
7A	1.909	1.919	1.922	1.930	1.982	.986	.872	1.380	2.000	3.800	.276	.178	.325	.366	.952	
8A	2.036	2.045	2.050	2.059	2.113	.843	.870	1.680	2.160	5.150	.226	.159	.328	.380	1.055	
4A	1.838	1.841	1.839	1.833	1.886	1.200	1.170	1.720	2.350	4.050	.351	.248	.444	.460	1.115	+25°C
7A	1.860	1.867	1.868	1.874	1.920	.980	.938	1.490	2.110	3.810	.275	.192	.351	.386	.955	
8A	2.175	2.182	2.183	2.190	2.246	1.130	1.200	2.140	3.170	5.880	.302	.220	.417	.462	1.205	
4A	1.775	1.775	1.775	1.776	1.801	1.630	1.710	2.460	3.180	4.900	.476	.362	.635	.623	1.348	-25°C
7A	1.824	1.825	1.825	1.825	1.859	1.420	1.430	2.030	2.630	4.260	.398	.293	.478	.482	1.070	
8A	2.014	2.016	2.100	2.101	2.138	1.710	2.140	3.880	5.500	9.560	.457	.392	.758	.800	1.960	
4A	1.721	1.715	1.692	1.687	1.704	2.330	2.500	3.780	3.950	5.230	.681	.530	.847	.772	1.940	-55°C
7A	1.775	1.773	1.762	1.761	1.792	1.810	1.850	2.390	2.960	4.700	.509	.378	.563	.542	1.175	
8A	2.033	2.022	1.920	1.980	2.001	3.400	5.110	10.470	15.460	28.260	.910	.938	2.040	2.225	5.795	

TABLE A6

Percent Capacitance Versus Frequency and Temperature
Metallized Polycarbonate

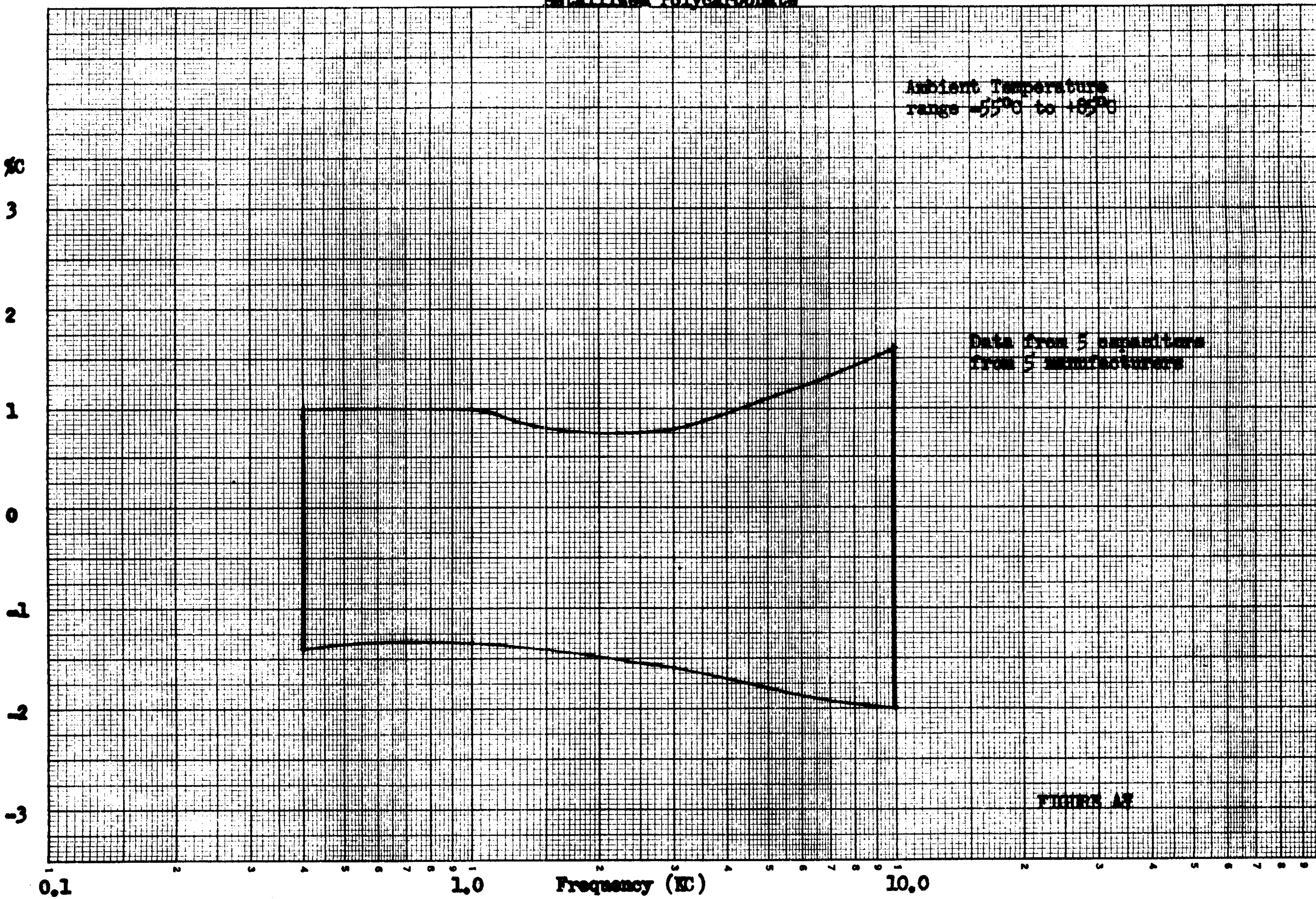


FIGURE A7

Percent Dissipation Factor Versus Frequency and Temperature
Metallised Polycarbonate

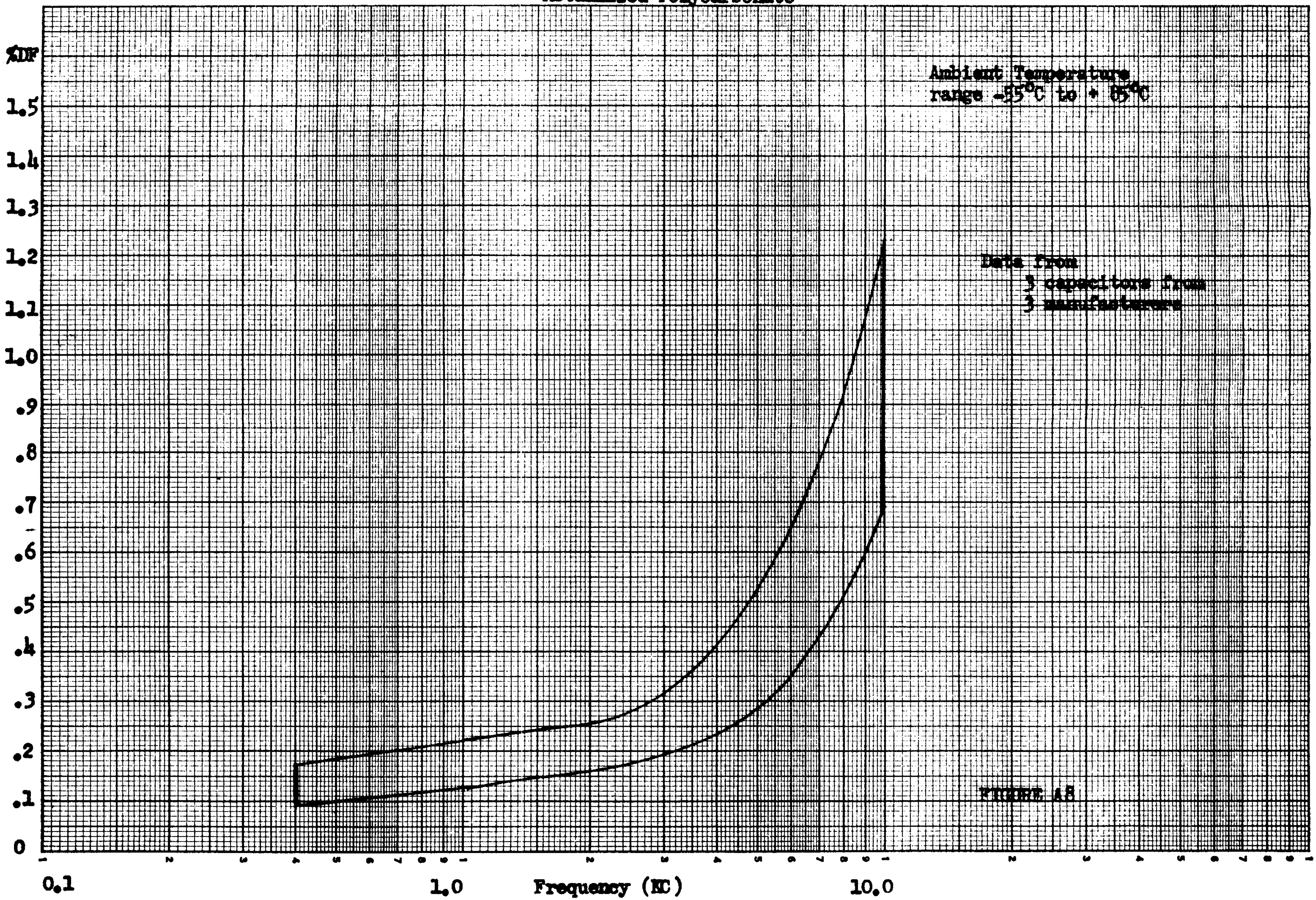


FIGURE A8

Percent Capacitance Versus Frequency and Temperature
Polycarbonate/Foil

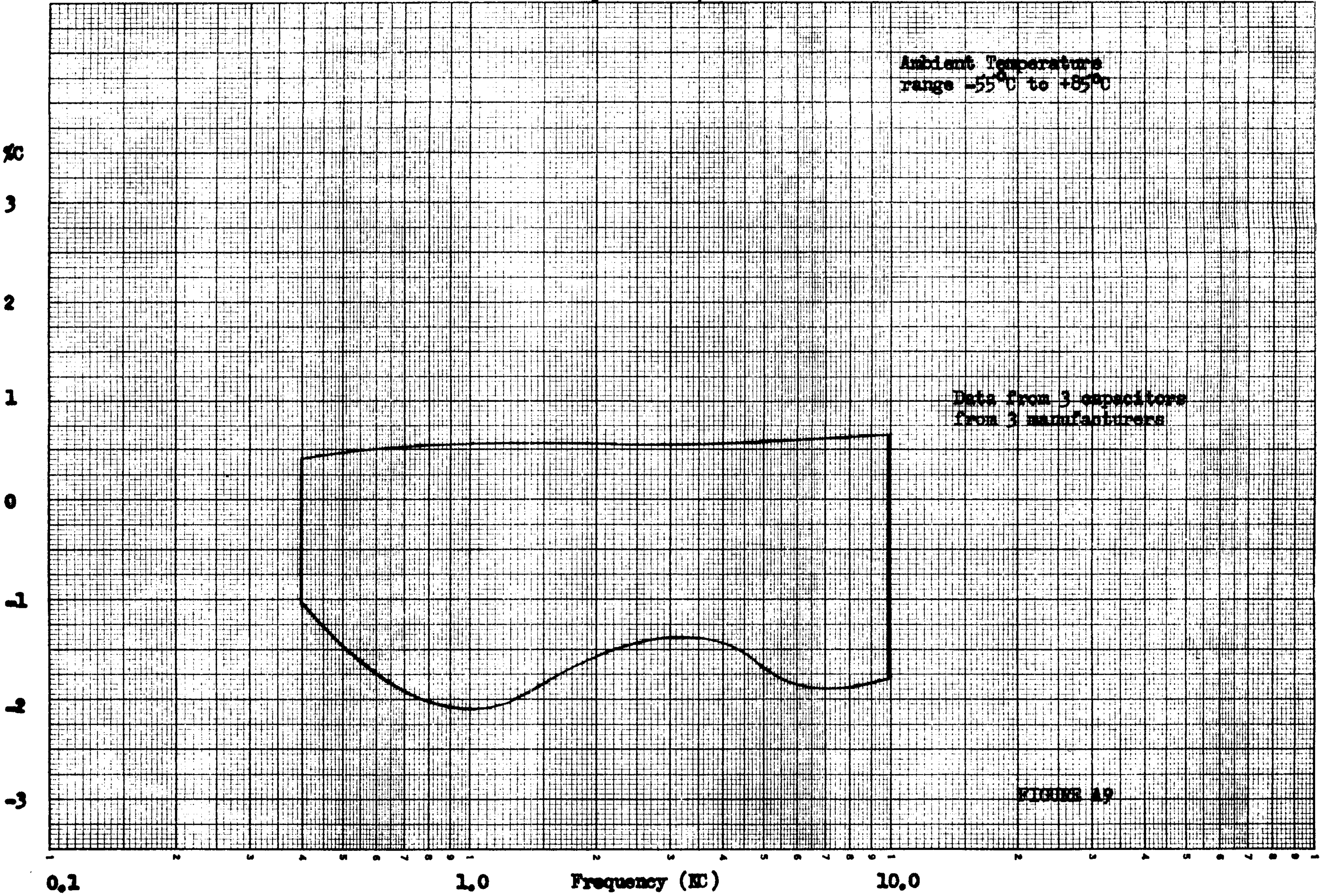


FIGURE A9

Percent Dissipation Factor Versus Frequency and Temperature
Polycarbonate/Foil

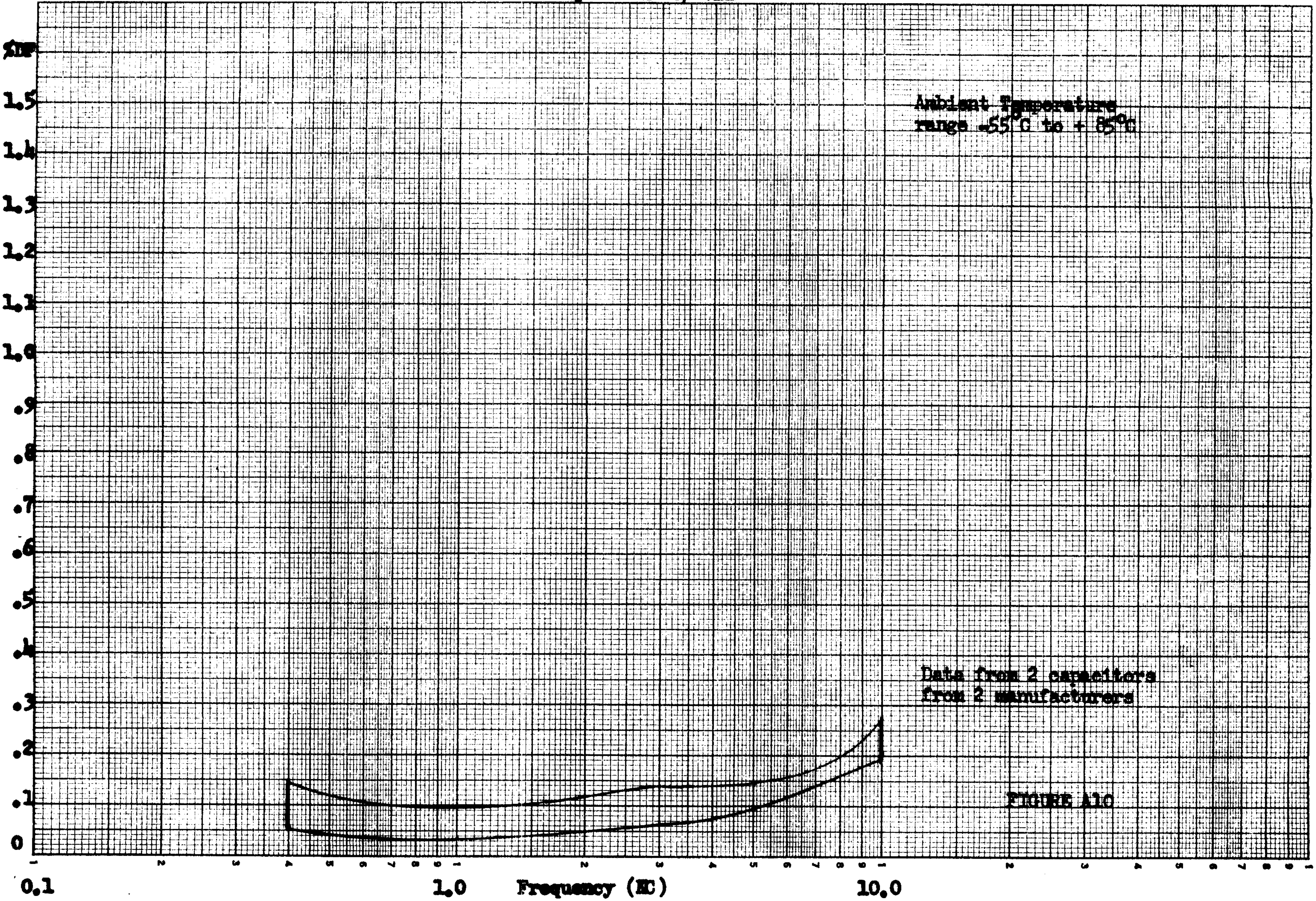


FIGURE A10

Percent Capacitance Versus Frequency and Temperature
Metallised Paper

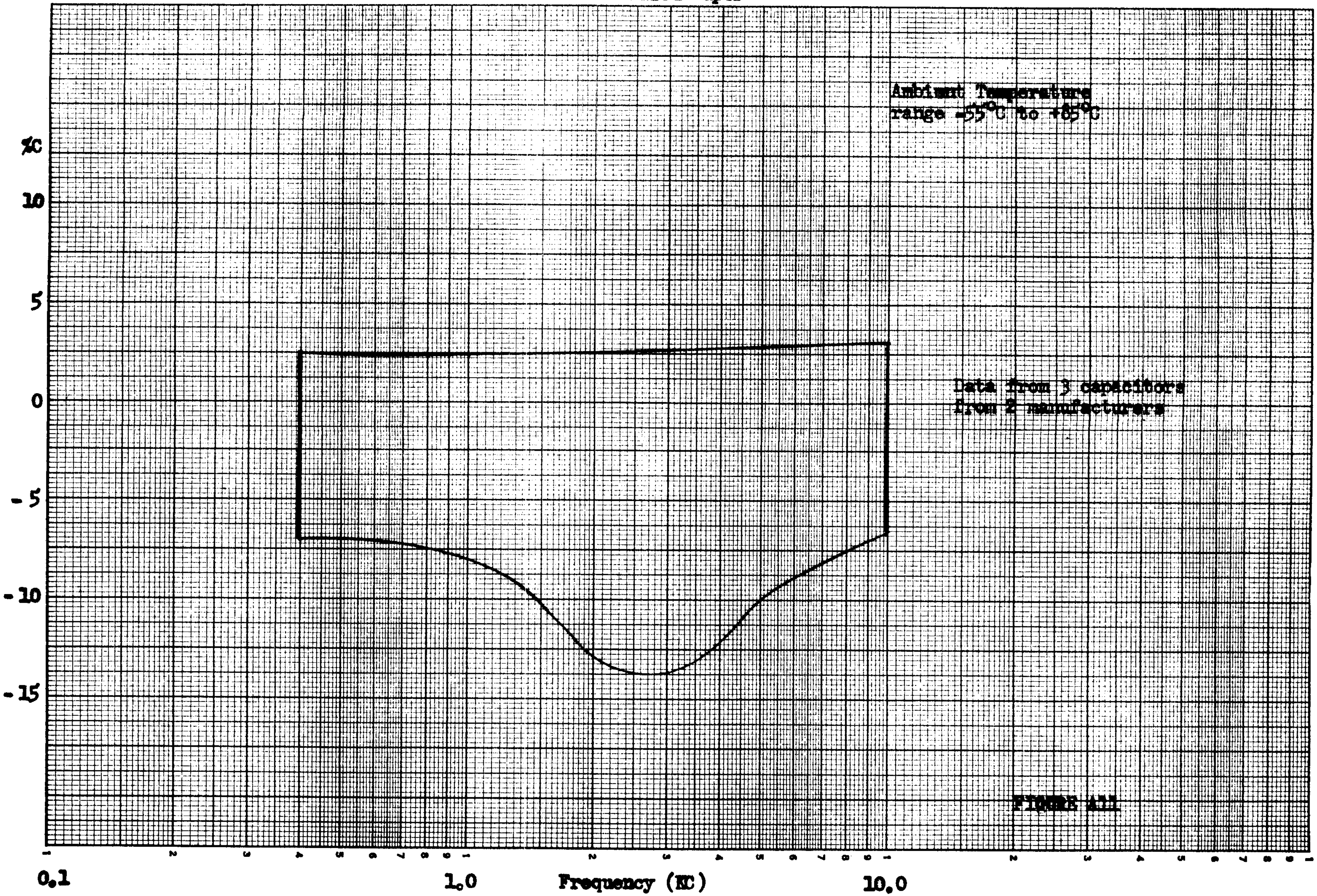


FIGURE A11

Percent Dissipation Factor Versus Frequency and Temperature
Metallised Paper

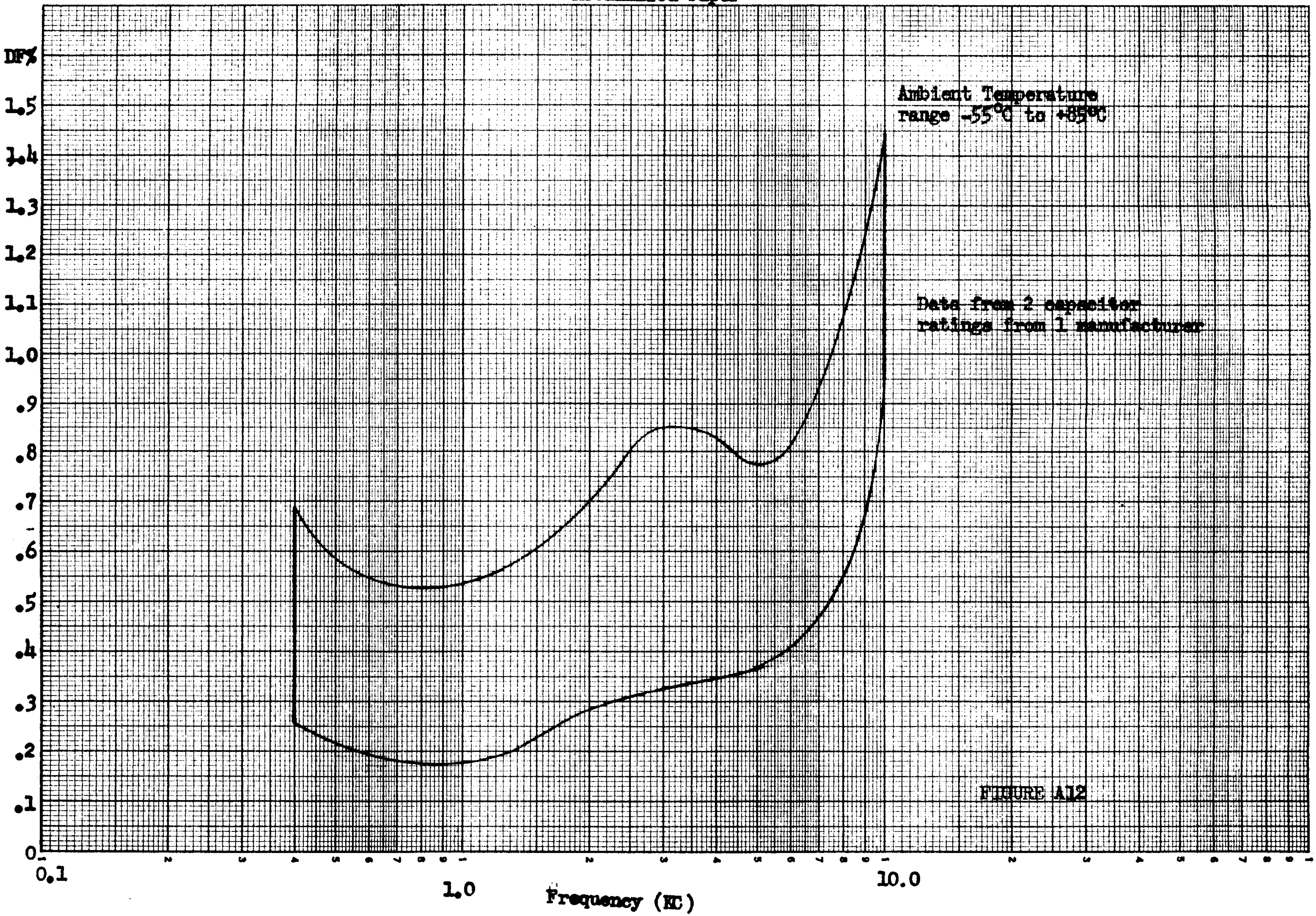


FIGURE A12

APPENDIX B

Capacitance and Dissipation Factor Life Test Data

Test data contained in Table B1 were obtained before and after a 1000 hour life test in 85°C ambient with 400 cps voltage applied.

Capacitors with 400 VDC rating were energized with 325 volts peak. Capacitors with 200 VDC rating were energized with 212 volts peak. The 135 and 157 volt DC capacitor ratings were energized with 162 volts peak.

The 325 volt peak limitation was maintained to prevent damage to the capacitors from corona.

An example of the method of obtaining correction factors for the dissipation factor is given:

Bridge value of dissipation factor for capacitor number 1B before life test is 0.316% and is equivalent to the corrected DF% of 0.132 from Table A1 at 1 kilocycle.

Bridge value of dissipation factor for capacitor number 1B after life test is 0.326%. The corrected DF% is obtained by:

$$\frac{0.326\%}{0.316\%} \times 0.132 = 0.136\%$$

CAPACITOR TEST DATA

BEFORE AND AFTER LIFE TEST

25°C AMBIENT AND @ 1 KILOCYCLE TEST CONDITIONS

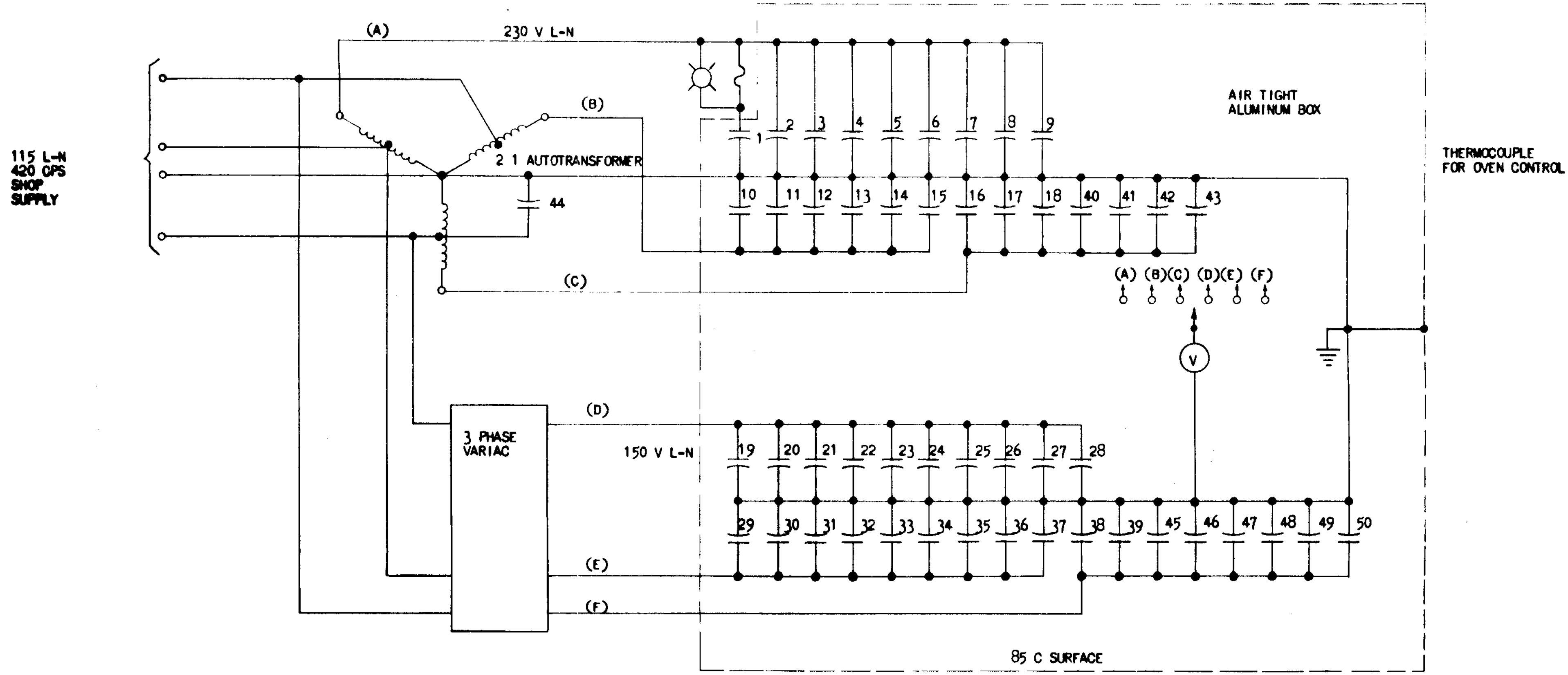
BEFORE LIFE TEST	BRIDGE MEAS.		CORRECTED		AFTER LIFE TEST	BRIDGE MEAS.		CORRECTED		BEFORE LIFE TEST	BRIDGE MEAS.		CORRECTED		AFTER LIFE TEST	BRIDGE MEAS.		CORRECTED	
CAP. No.	C (MFD)	DF (%)	DF (%)	CAP. TYPE	CAP. No.	C (MFD)	DF (%)	DF (%)		CAP. No.	C (MFD)	DF (%)	DF (%)		CAP. No.	C (MFD)	DF (%)	DF (%)	
1B	.984	.316	.132	MPC	1B	.977	.326	.136	MPC	15E	2.991	.803	–	MPC	15E	3.000	.428	–	MPC
1C	.995	.330	.138	MPC	1C	.988	.325	.136	MPC	10D	1.985	.332	.055	PCF	10D	2.005	.271	.045	PCF
1D	.965	.353	.148	MPC	1D	.987	.327	.137	MPC	11C	2.963	.365	.038	PCF	11C	2.962	.287	.030	PCF
1E	.963	.361	.151	MPC	1E	.957	.344	.144	MPC	11D	3.097	.377	.039	PCF	11D	3.104	.311	.032	PCF
3A	2.688	.340	.178	MPC	3A	2.713	.323	.162	MPC	11E	3.018	.379	.039	PCF	11E	3.020	.301	.031	PCF
3E	2.686	.354	.186	MPC	3E	2.680	.322	.169	MPC	17B	5.470	.365	–	PCF	17B	5.500	.452	–	PCF
5A	1.934	.336	.134	MPC	5A	1.925	.303	.121	MPC	18B	3.310	.445	–	PCF	18B	3.334	.428	–	PCF
5B	1.956	.332	.132	MPC	5B	1.947	.310	.123	MPC	4C	1.939	1.100	.266	MP	4C	1.958	1.132	.273	MP
5C	1.931	.343	.136	MPC	5C	1.922	.304	.121	MPC	4D	1.871	1.010	.244	MP	4D	1.995	.991	.239	MP
5D	1.963	.337	.134	MPC	5D	1.955	.308	.122	MPC	4E	1.864	1.010	.244	MP	4E	1.879	.991	.226	MP
5E	2.002	.332	.132	MPC	5E	1.995	.313	.124	MPC	7B	1.856	.776	.188	MP	7B	1.873	.770	.186	MP
6A	1.981	.390	.139	MPC	6A	2.003	.401	.143	MPC	7C	1.868	.768	.186	MP	7C	1.885	.744	.180	MP
6C	1.923	.379	.135	MPC	6C	1.943	.379	.138	MPC										
6E	1.965	.381	.136	MPC	6E	1.983	.370	.132	MPC										
12E	3.008	.366	–	MPC	12E	3.020	.352	–	MPC										
13A	3.277	.456	–	MPC	13A	3.307	.360	–	MPC										
13B	3.274	.437	–	MPC	13B	3.309	.356	–	MPC										
13C	3.194	.431	–	MPC	13C	3.226	.341	–	MPC										
13D	3.268	.440	–	MPC	13D	3.280	.348	–	MPC										
13E	3.219	.435	–	MPC	13E	3.255	.347	–	MPC										
14A	2.783	.377	–	MPC	14A	2.813	.363	–	MPC										
14C	2.721	.370	–	MPC	14C	2.736	.350	–	MPC										
14E	2.774	.442	–	MPC	14E	2.806	.427	–	MPC										
15B	3.056	.402	–	MPC	15B	3.067	.362	–	MPC										
15D	3.039	.802	–	MPC	15D	3.047	.443	–	MPC										

MPC - METALLIZED POLYCARBONATE

PCF - POLYCARBONATE/FOIL

MP - METALLIZED PAPER

TABLE BI



NOTES
1. EACH CAPACITOR FUSED AS SHOWN BY CAPACITOR 1.
LIGHTS AND FUSES OUTSIDE OVEN.

CAPACITOR TYPES

MP	1-2	2 UF	400 VDC
PCF	3-5	1 UF	400 VDC
MPC	6-10	2 UF	400 VDC
MPC	11-13	2 UF	400 VDC
MPC	14-16	2 UF	300 VDC
MPC	17-18	2.55 UF	400 VDC
MP	19-	2 UF	200 VDC
PCF	20-23	2 UF	200 VDC
MPC	24-26	3 UF	200 VDC
MPC	27-29	3 UF	200 VDC
MPC	30-34	3 UF	200 VDC
MPC	35-39	3 UF	200 VDC
MPC	40-43	1 UF	400 VDC
PCF	44	5 UF	157 VDC
MP	45	2 UF	200 VDC
PCF	46-48	3 UF	135 VAC
MP	49	2 UF	200 VDC
PCF	50	3 UF	135 VAC

PCF - POLYCARBONATE FILM AND ALUMINUM FOIL CONSTRUCTION
MPC - METALLIZED POLYCARBONATE FILM CONSTRUCTION
MP - METALLIZED PAPER CONSTRUCTION

FIGURE B1

ELEMENTARY FOR CAPACITOR LIFE TEST 85 C.

Calorimeter Calibration Data Curve

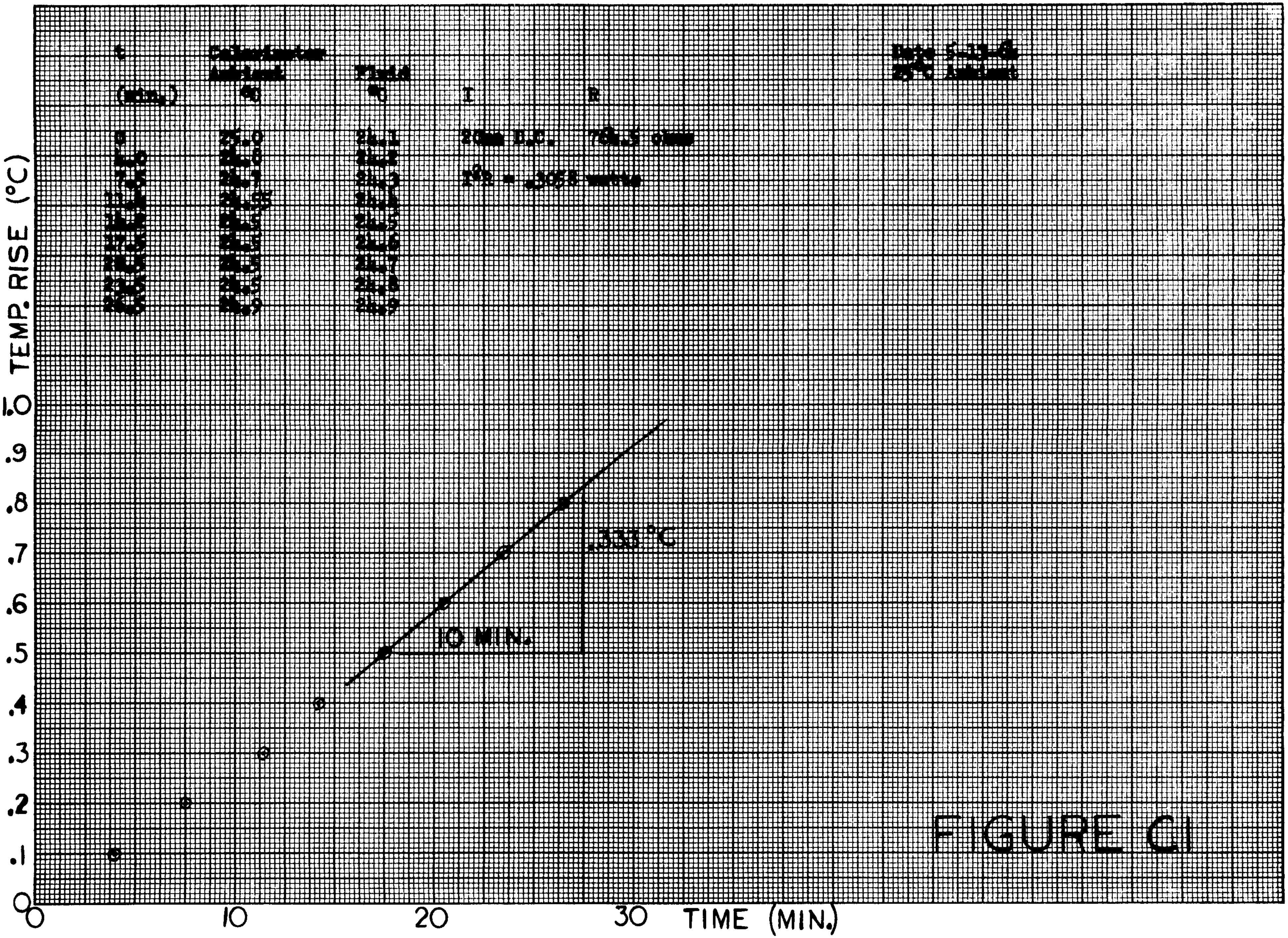


FIGURE C1